ASSESSING THE INFLUENCE OF HIGH SCHOOL PRACTICES AND COMMUNITY CHARACTERISTICS ON ADOLESCENT OBESITY

by

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ABSTRACT

This study examined the influence of federal obesity prevention policy on school practices and adolescent obesity. The study also examined the influence of community characteristics on adolescent obesity. A sample of all high schools participating in both the 2004 and 2008 School Health Profiles survey years was used to analyze practices over time. Adolescent and family attributes were obtained from the Utah Population Database. School characteristics were accessed via the Common Core of Data. Community characteristics were generated from the Behavioral Risk Factor Surveillance system data collected by the Utah Department of Health for 61 small statistical areas in Utah. Bivariate and multinomial analyses were performed to model the relationship of school practices and community level characteristics with adolescent overweight and obesity. Schools in districts with mandated wellness policy tenets were no more likely to report school environment or health education practices than schools with weaker or no policy tenets. Of the 42 school practices examined, only exempting students from PE was associated with the risk of obesity (RR_a=0.76,95% CI: 1.16-1.74, p<0.02). Maternal obesity tripled the risk adolescent overweight (RR_a=3.08, 95% CI: 2.54-3.76, p<0.001) and resulted in a six-fold risk of obesity (RR_a=6.06, 95% CI: 4.988-7.52, p<0.001). The proportion of obese adults in a community was associated with adolescent overweight (RR_a = 1.45, 95% CI: 1.04-1.24, p<0.008) and obesity (RR_a =1.19,95% CI: 1.05-1.36, p<0.006). Community education level was protective for adolescent obesity (RR_a=0.81, 95% CI: 0.69-0.97, p<0.024). Future research is needed to develop tools that assess the ability of policy initiatives to produce meaningful and sustainable changes in school practices. Adolescent obesity prevention policies and programs should address community disparities in adult obesity, income and education.

To Doris Disbrow, Barbara Abrams and Zak Sabry who developed my interest in public health nutrition, to Tim Metos for his support and to Thomas and Grace in hope that you will have a healthy life, full of learning.

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CHAPTER 1

INTRODUCTION

Background and Significance

The prevalence of adolescent obesity in the United States has increased from 5% to18% in the past three decades.[1-4] Recent reports suggest that while overweight and obesity among adolescents is persisting at an all-time high, the upward trend has reached a plateau among females, and males with lower body mass index (BMI) values.[2,5] An increase in the prevalence of obesity has been noted among all ethnicities, both genders, and all socioeconomic classifications.[6-8]

In Utah, the percentage of students in high school who report heights and weights that are classified as obese increased from 4.2% in 1999 to 8.7% in 2007. During the same time, the proportion of overweight adolescents increased from 9.1% to 11.7%. Similar to national trends, the Utah Youth Risk Behavior Survey (YRBS) detected a plateau in obesity in 2009 with 6.4% of high school students classified as obese.[9] The YRBS results are limited by their reliance on self-reported height and weight and active parental consent. It has been noted that boys tend to over-report their heights, and girls tend to under-report their weights.[10] Active parental consent, which is required in Utah, produces lower rates of unhealthful behaviors when compared to passive consent.[11] Both these factors suggest underestimation of adolescent overweight and obesity in Utah. Using the conservative estimate provide by YRBS, approximately 20.4% of Utah adolescents are at an unhealthful weight.[11]

The health implications for overweight and obese adolescents include hypertension, type II diabetes, asthma, joint problems, sleep apnea, liver abnormalities and depression.[12] Additionally, there are social and emotional issues for overweight and obese adolescents

including negative stereotyping, stigmatization, poor peer interaction and discrimination.[13,14] In the long-term, adolescents who are overweight and obese are more likely to carry excess adiposity into adulthood.[15] This increases their risk of cardiovascular disease, diabetes, osteoarthritis, and certain types of cancer. Obese adolescents and adults have fewer academic and employment opportunities.[15]

Schools have been described as natural settings for population-based interventions to address overweight and obesity.[12,16,17] Students spend up to eight hours per day at school and participate in meals, snacks and activity patterns that influence overall energy balance. Despite the appeal of the school setting, results of school-based interventions have been mixed. Most first generation studies focused on individual changes in knowledge and behaviors using curriculum-centered models. These studies report limited success in producing changes in BMI or other indicators of adiposity.[18] Tools used to measure the food and physical activity environment at school are limited and often poorly assessed.[19,20] Further, the research literature is limited by a small evidence base. Of the eight randomized controlled trials published, the two reporting statistically significant changes in BMI are characterized as "policy-based" and were conducted in upper-elementary and middle schools.

Sallis conducted a 2-year randomized field trial at 24 middle schools.[33] Physical activity interventions included the provision of 15 hours of instructor training, provision of new curriculum materials, increasing amounts of activity equipment available to students throughout the day, obtaining volunteers to lead after-school activity programs and changing policies to make activity areas available to students during breaks and after school. Additionally, a policy committee including students, staff and parents developed standards for new practices in the school such as class credit for physical activity outside of class and promotion of physical activity via newsletters.

The nutrition intervention worked with school food service staff, food vendors and student stores to reduce the dietary fat content of all foods served at school. This included 11 hours of training for food service staff, recipe modification, adoption of salad bars, substitution of higher fat foods with low-fat items in school stores, and promotion of low-fat foods with signs

and newsletters. The policy committee developed a nutrition policy stating goals for fat content of foods served at school stores.

The results showed a decrease in BMI for boys. BMI decreased from 20.12 to 19.84 kg/m^2 in the intervention group compared to an increase from 19.68 to 20.02 kg/m^2 in the control group (F=4.60, p-0.044, d= 0.83). No changes were found for BMI in girls (F=0.09, p=0.77, d=-0.12). The results demonstrated a greater increase in physical activity among the intervention schools than the control schools (p = 0.00) with an effect size of d = 1.10. No differences were found for total fat or saturated fat (F=0.781, d=0.03).

A second policy based school intervention, the School Nutrition Policy Initiative (SNPI) was held in 10 elementary schools in one school district; the intervention was for student in grades 4-6.[21] Schools were matched on type of food service and school size. Students were assessed at baseline and 2 years later and compared to students at control schools. This study included nutrition education in the classroom, nutrition policy, staff training, family outreach and social marketing. The researchers did not include an in-school physical activity component. Instead, promotions and classroom education focused on physical activity with the family and reductions in television viewing.

Height and weight were measured annually at school. Dietary intake, physical activity and sedentary behavior were measured using the Youth/Adolescent Questionnaire, which was self-administered.[22] The primary outcome was defined as the incidence of overweight and obesity, while secondary outcomes included self-reported dietary intake of calories, fat, fruits and vegetables, physical activity and sedentary behavior. Findings include a statistically significant decrease in the incidence of overweight. Compared to the 14.9% who became overweight in the control schools, 7.5% of students became overweight in the intervention group. After controlling for gender, race and age, the predicted odds of incidence of overweight were 33% lower for the intervention group (OR: 0.67; 95% CI: 0.47-0.96; p< .05). Students in both the intervention and control schools showed decreases in self-reported energy, fat, fruit and vegetable intake and there were no differences between the two groups in reported

physical activity. Inactivity was reported as 4% lower in the intervention group than in the control group (OR: 0.96; 95%CI: 0.94-0.99, p<.01).

National efforts encourage schools, school districts, state boards of education and state legislatures to develop nutrition and physical activity policies and laws. The policy initiative is based upon the modest effectiveness of randomized controlled trials in elementary and middle schools. In 2004, policy efforts were expanded as the result of a federal mandate. The Child Nutrition Reauthorization Act (CNRA) required each school district to have "a local wellness policy that includes goals for nutrition education, physical activity and other school-based activities designed to promote student wellness in a manner that the local educational agency determines is appropriate."[23] School districts across the nation were required to seek community input and develop these policies for the 2006-2007 school calendar and onward, and were instructed to address five content areas: 1) goals for nutrition education and physical activity, 2) nutrition guidelines for foods provided at school, 3) assurance that guidelines for school meals meet the United States Department of Agriculture (USDA) guidelines, 4) a plan for monitoring the policy, and 5) involvement of parents, students, representatives of the school food authority, the school board, school administrators, and the public in the development of school wellness policy content. National estimates show that over 50% of school districts had written a school wellness policy by the end of 2006 and 99% by the end of 2009.[24,25] In Utah, 30 of 40 school districts had a wellness policy by the beginning of the 2006-2007 school year and 36 had policies by the end of 2009.

Policies can only work if they are used. School wellness policies have been described as natural experiments occurring with little base-line data collection and wide variation in design and implementation.[26] There are several questions that need to be answered to determine if the CNRA approach to adolescent obesity is effective. First, the school policy must be written and accepted by the school board. Next, the written content of the policies can be described in terms of compliance and content.[27-29] National samples have been used to evaluate wellness policy content.[25] At the state level, there have been 4 objective analyses in Connecticut, Georgia, Pennsylvania and Utah.[30-33] The Georgia and Utah analyses are the only published

peer-reviewed studies to date. Overall, the quality of school district wellness policies varies greatly. A majority of districts meet the general requirements of the CNRA. Policy content is underdeveloped in quality and comprehensiveness.[34]

Little is known about implementation of school wellness policies, especially in high schools. Two studies of high school implementation practices have been published. The first study reported on vending machine content in 3 high schools. Prior to the wellness policy, 48% of vending machine content was 'low in nutrient density'. Post wellness policy, low nutrient dense foods made up 30% of the offerings.[35] The second study examined foods offered in vending machines and a la carte in the school cafeteria in 16 schools. Post wellness policy, 68.6% of vending machine selections and 79.9% of a la carte selections did not meet the Institute of Medicine recommendations for competitive food offerings.[36] There is no published research regarding high school implementation of physical activity following the wellness policy initiative.

Ultimately, it is useful to determine if school policies and practices are associated with BMI. In Utah, research indicates adolescent obesity prevalence is lower where school districts have mandated wellness policies.[37] No other studies have examined overweight or obesity outcomes resulting from the CNRA. In order to accurately evaluate the impact of the federal wellness policy, a better understanding of the relationship of school practices and adolescent BMI is needed.

Adolescent overweight and obesity are influenced by individual, family and community factors in addition to school characteristics. Previous research indicates that being male, Black, American Indian or Pacific Islander is associated with overweight and obesity.[3] Parental health and BMI are associated with adolescent BMI[38] as are family eating and physical activity behaviors.[39,40] Research shows that the income and education level of a community are associated with adolescent overweight and obesity.[41,42] Few studies include individual, family and school factors when assessing the role of community characteristics on adolescent obesity.[43] The final aim of this study is to assess how individual, family, school and community factors jointly influence the risk of overweight and obesity among adolescents.

Specific Aims

The specific aims of this study were to: 1) compare high school obesity prevention practices before and after the implementation of the federal wellness policy mandate 2) examine the relationship of exposure to school wellness practices and adolescent BMI and 3) investigate the relationship of community influences and adolescent BMI in the context of individual, family and school characteristics.

Methods and Analysis Process

Steps in the project are listed below; the methods are described in greater detail for each specific outcome in Chapters 2, 3, and 4.

1. After Institutional Review Board approval, obtained School Health Profiles, Utah Population Database, Common Core, and Behavioral Risk Factor Surveillance Survey data.
2. Selected practices congruent with federal wellness policy, identified schools participating in *Profiles* principal and/or health teacher survey in 2004, 2006, 2008.
3. Obtained high school boundaries from school districts. Mapped high school boundaries. Placed adolescents in high school boundaries using address on driver's license.
4. Each geo-coded student was then linked to the results of the Profiles survey based on school and the year they received their license.
5. Compared high school practices 2004-2008. Analyzed implementation by demographic variables; district wellness policy content, nutrition, physical activity and training domains; and among high schools in same district.
6. Conducted bivariate analysis of individual, family, school characteristics and school practices.
7. Conducted multivariate analysis of individual, family, school characteristics and school practices.
8. Selected variables from Behavioral Risk Factor Surveillance Survey to quantify additional community characteristics.

9. Conducted multivariate analysis including additional community characteristics in the model described in #7

Summary

The three studies are presented in detail in Chapters 2, 3, and 4, followed by a conclusion (Chapter 5).

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CHAPTER 2

ARE OBESITY PREVENTION PRACTICES IN HIGH SCHOOLS ASSOCIATED WITH SCHOOL DISTRICT WELLNESS POLICIES?

Abstract

PURPOSE: This study examined obesity prevention practices in Utah high schools before and after implementation of the 2004 Child Nutrition and WIC Reauthorization Act.

METHODS: Principals and health teachers completed questionnaires regarding nutrition and physical activity practices in high schools in 2004, 2006 and 2008 as part of the School Health Profiles survey. A sample of all high schools participating in both 2004 and 2008 survey years was used to analyze practices over time and to determine implementation patterns based on practice domains and demographic characteristics of high schools. District wellness policy content was compared with the practices reported by high schools, both overall and within districts.

RESULTS: Each nutrition and physical activity topic, such as teaching about healthy meals or the benefits of exercise, was taught in >75% of high schools in 2004 and 2008. Schools in districts with mandated wellness policy tenets were no more likely to report school environment or health education practices than schools with weaker or no policy tenets. Obesity prevention practices were distributed across many schools in each survey year. No similarities were found among high schools in the same school district. From 2004-2008, the availability of energy dense snacks and beverages decreased 3-5 percentage points. However 92% of schools offered items in 3 of 4 categories of 'junk food'. Thirty-six percent of principals reported that students could be exempt from physical education classes in 2004 compared to 67% in 2008.

CONCLUSION: Few improvements were detected in school obesity prevention practices two years after the federal wellness policy mandate. No significant relationship was found between a

mandated policy guideline and a related school practice. Future research is needed to develop tools that assess the ability of policy initiatives to produce meaningful and sustainable changes in school practices.

Introduction

The persistent prevalence of high body mass index (BMI) among adolescents is a significant public health issue. Adolescent obesity in the United States tripled between 1980 and 2002, reaching a prevalence of 17.4% among 12-19-year-olds, with an additional 34% of adolescents considered overweight.[1] Periodic examinations of adolescent body mass index completed since 2002 indicate that the prevalence has not decreased.[2] Many of these adolescents will experience short-term health issues such as high blood pressure and elevated lipid levels and will remain overweight or obese into adulthood.[3] As a result, they will experience chronic diseases related to obesity such as type 2 diabetes,[4] coronary heart disease [5] and osteoarthritis.[6] The relationship between obesity, health and broad societal issues including academic success,[7-9] health care costs,[10] military preparedness[11] and workplace productivity, prompts calls from the Institute of Medicine,[12] the Surgeon General[13] and the White House[14] for all sectors of society to take preventive action.

School Policy Approaches to Obesity Prevention

School policy approaches have emerged as a preferred tool for population-based obesity prevention in youth and gained momentum with The Child Nutrition and WIC Reauthorization Act of 2004 (CNRA).[15] The CNRA requires each school district to develop a wellness policy that sets nutrition standards for foods available on school campuses and establishes guidelines for physical activity, nutrition education, and other school-based wellness activities. Wellness policies are now in place in 99% of school districts in the United States and reach 80% of students.[16] The rationale for school-based strategies is that schools have a unique opportunity to reach adolescents as this is the environment where they spend a majority of their time away from home.[12,17] In schools, there is a tradition of educating adolescents about healthful food choices and physical activity through required health education and physical education courses,[18] and

schools can influence adolescent behavior by providing environments that minimize energy-dense "junk" foods and increase opportunities for physical activity.[19,20]

The premise that schools are natural venues for obesity prevention is supported by randomized controlled trials in which school environments are shown to influence students' health behaviors through nutrition education, food choices and physical activity.[21-24] These studies suggest that in a supportive environment with adequate resources, energy balance and weight gain can be altered. Few studies examine whether a national policy such as the CNRA produces similar changes.[25,26] Further, studies that include high schools and adolescent students are limited. In adolescence, autonomy and personal identity are developing. Nutrition education, physical education and healthful environments are essential to both reinforce what has been learned previously and to help adolescents apply skills to their current stage of life.[27]

Research examining the influence of policies established in response to the CNRA is primarily limited to analysis of the policy content.[16,28-31] Implementation is rarely evaluated in secondary schools and results are mixed. Decreases in the purchases of sugar-sweetened beverages, candy, and other low-nutrient density foods are reported in regional studies,[19,32] while a national study indicates no relationship between school district policies and competitive food practices at schools.[20] Physical education is addressed in the majority of wellness policies,[16] yet the evidence to date suggests that in rural elementary schools, the net time allotted to physical activity does not change post CNRA.[33] A recent report examining teens in California concluded that 38% of secondary students participate in physical education despite state policy requiring 400 minutes of physical education every 10 days. The low participation rate was partly explained by the practice of exempting high school students from PE.[34] Information on the implementation of school wellness policies in high schools is needed to inform ongoing efforts.

The primary objective of this study was to assess wellness policy implementation in Utah high schools using survey data obtained from principals and health education teachers. Obesity prevention practices in high schools are quantified before (2004) and after (2008) the July 2006 deadline for having policies in place as mandated in the CRNA. Additionally, this study examined implementation patterns based on the demographic characteristics of the individual high schools,

and the relationship between school district wellness policy content and reported high school practices.

Methods

Data for this study were derived from three sources: The School Health Profiles survey *(Profiles)* provided information on wellness policy implementation as reported by high school principals and lead health teachers, the Common Core of Data (CCD) provided school demographic information, and a previously described survey provided information on policy content.[29]

Profiles is a biennial survey of public school principals and lead health education teachers in secondary schools that captures information on physical activity, foods provided at school, reproductive health, violence prevention, HIV/AIDS prevention, and tobacco prevention.[35] States participating in the survey may select either all public secondary schools, or a systematic, equal-probability representative sample of schools. The Utah *Profiles* sample includes all public high schools with the exception of charter and alternative schools resulting in 109 high schools in 2004 and 113 in 2008. Separate questionnaires for principals and lead health education instructors are sent to each school to be self administered and returned to the Utah Department of Health (UDOH). Follow-up phone calls and written reminders from UDOH are used to encourage participation and at the close of the survey, questionnaires are sent to the CDC for cleaning and editing. Final data sets are obtained upon permission from the Utah State Office of Education, which was granted for this study.

The CCD is a yearly survey of state education agency officials conducted by the U.S. Department of Education's National Center for Education Statistics.[36] The CCD collects information describing all public schools and school districts in the United States. Information from the 2008 CCD used for the present study includes urban/rural designations, school enrollment, race, ethnicity, and free and reduced price lunch participation.

To evaluate policy content, Utah school district wellness policies were requested from superintendent offices or obtained on-line in July 2006, immediately prior to the implementation

deadline for the CNRA.[29] School districts were required to include content in seven areas: 1) goals for nutrition education; 2) goals for physical activity; 3) goals for other school-based activities; 4) nutrition guidelines for all food available on campus during the school day 5) an assurance that guidelines for reimbursable meals shall not be less restrictive that the regulations and guidance issue by the Secretary of Agriculture; 6) establishment of a plan for measuring implementation; and 7) involvement of a diverse group of stakeholders, including parents, in developing the local wellness policy. Policies from 36 of the state's 40 school districts were obtained and reviewed for compliance. Further, when there was policy language addressing a requirement, the content was characterized as either "mandated" or "recommended." The methods used in the content analysis are described more fully elsewhere.[2]

Sample and Data Reduction

The sample consists of 86 Utah high schools that participated in either the *Profiles* survey of principals or the survey of health education teachers in both 2004 and 2008. The data aggregation process is shown in Figure 1. Responses to *Profiles* questions related to overweight and obesity prevention were identified and the intent of the questions confirmed by consulting the item rationale provided by the CDC Division of Adolescent Health.

The school nutrition environment was characterized by responses to questions about the availability of foods and beverages in vending machines, school stores, or canteens. This included chocolate, nonchocolate candy, high fat chips, sugar-sweetened beverages, fruits and vegetables. An additional question assessed the presence of a policy requiring fruits and vegetables at parties and celebrations. Twelve questions were used that asked whether specific nutrition topics were taught in required health education courses. The availability of teacher training in nutrition, health teachers' desire for nutrition training, and collaboration between health teachers and food service personnel were the three items measuring collaboration and training in the nutrition domain. The physical education/activity aspects of the school environment included

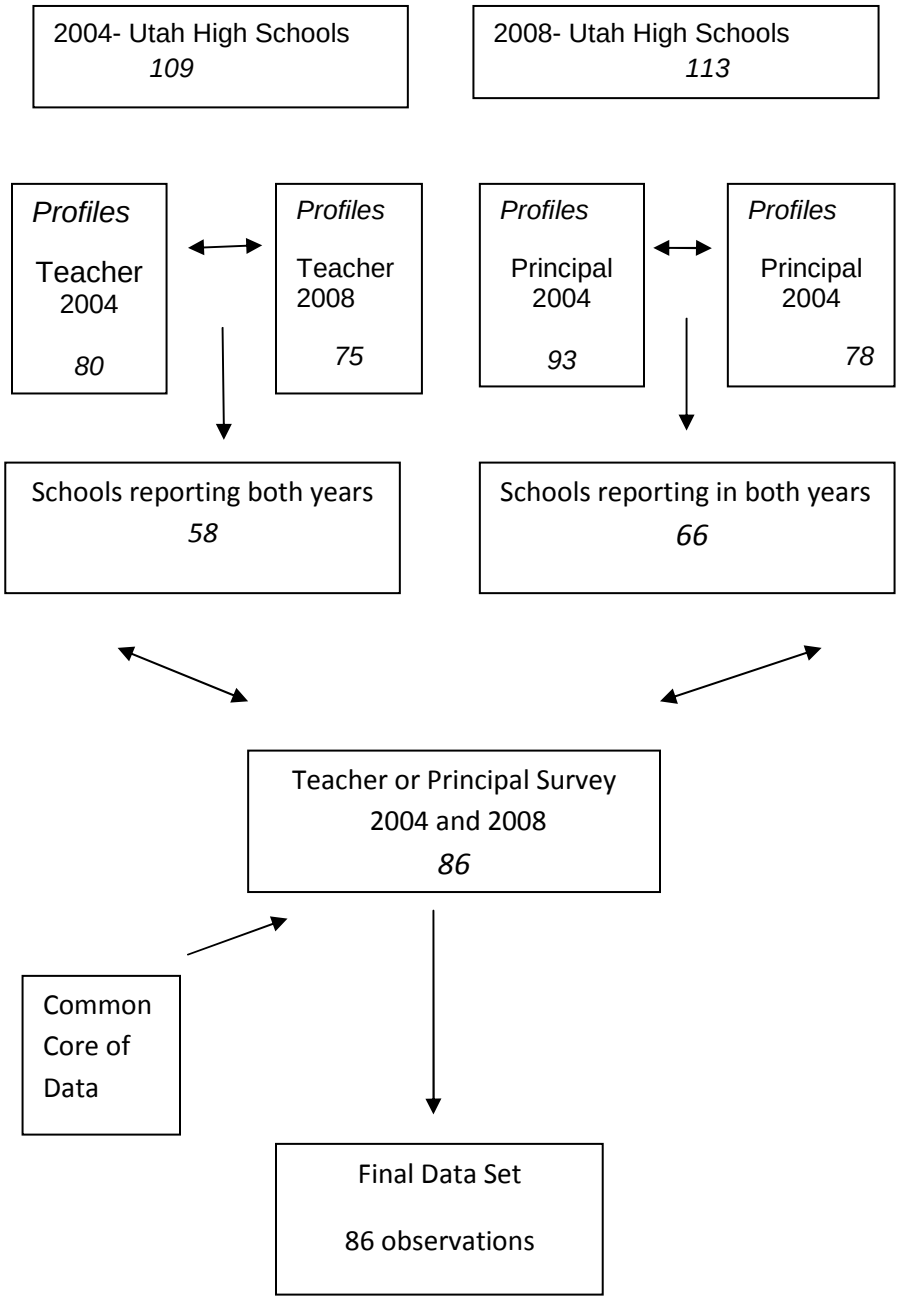

Figure 1. Data Aggregation: School Health Profiles Principal and Teacher Surveys and National Center for Health Statistics Common Core of Data for each High School.

two items assessing physical education requirements and five items assessing allowances for student exemption from physical education classes. Questions capturing teacher knowledge and application of eight specific physical activity curriculum topics provided measures of the curricular aspects of the school environment. Three variables addressing the availability of physical activity training for health teachers, their desire for physical education training, and the collaboration between health teachers and physical education teachers provide additional information on the school physical activity climate.

Each of the items from the 2004 Profiles survey was compared to the 2008 responses to assess the proportion of schools that: 1) reported the practice in 2004 and 2008; 2) reported the practice in 2004 and not in 2008; 3) did not report the practice in 2004 but reported it in 2008 and 4) did not report the practice in 2004 or 2008.

Differences in school practices by school characteristics including percent participation in free and reduced price lunch, school enrollment, race and ethnicity among schools in each of the four categories were tested using chi-square statistics. For many of the practices, a high percentage of the schools reported doing that activity. The pattern of the practices reported by each school were examined to determine if a specific set of schools were consistently not adhering to a practice or whether the instances where a practice was not carried out was occurring across the sample schools.

Finally, the relationship between the school district policy content and related practices reported in the *Profiles* survey was assessed using contingency tables. All analyses were conducted using SAS version 9.2 (SAS Institute, Inc, Cary, NC).

Results

Characteristics of the sample high schools are shown in Table 1. As of 2008, Utah high schools were primarily urban schools with high enrollment. Overall, the sampled student population had less diversity in race and ethnicity than the national student population but mirrored changes in Utah in the past 10 years.[37] The sample included 7 high schools in which

Table 1. Characteristics of Utah High Schools, n=86 (79%)

	Mean or %	SD	10%ile	90%ile
%Rural[a]	36.9	NA	0	1
Free/reduced price lunch (%students eligible)	32.5	19.6	4.2%	98.5%
Student enrollment (n)	1010.9	741.7	116.0	1950.0
Race/Ethnicity				
%Pacific Islander	1	2	2	1.3
%Black	1.1	1.4	0	2.6
% Asian	2.5	2.7	0	6.1
% American Indian	5.3	1.7	0.16	7.7
% Hispanic	10.6	11.4	1.7	2.6
%White	80.3	19.4	54.2	94.8

[a]Rural includes the geographic classifications used by the Common Core of Data (CCD): "rural remote," "rural fringe," and "rural distant."

Hispanic students comprise the largest population and 2 high schools where 90-100% of the students are American Indian. The proportion of high school students receiving free or reduced price lunches ranged from 4% to 98%, with a mean of 32%. This was comparable to the national average of 33%. High schools in the sample had a mean pupil-to-teacher ratio of 22, higher than the national average of 15.[38]

The schools of Utah are quite diverse and cannot be combined into descriptive categories. The strongest pattern is found with income. The proportion of students eligible for free or reduced price lunch was higher in rural high schools (85% vs. 15%, $p< 0.001$) and in schools with <1000 students (86% vs. 14%, $p<0.001$). Schools with greater racial diversity tended to be schools with <1000 students (97% vs. 3%, $p<0.001$. Race and locale were independent, ($p=0.6730$), primarily because high schools in the Salt Lake City district (urban) and the San Juan district (rural) both had high schools ranking among the most racially diverse in the state. Characterizing schools by locale, it was noted there were few rural schools with high enrollments, 3 above the mean of 1,011.

The prevalence of several school environment practices was examined. “Junk foods” were readily available in virtually all schools in 2004, and there was very little change between 2004 and 2008. For example, 92% of high schools offered items in three of four categories of junk food (chocolate candy, other candy, high fat chips, and sugar sweetened beverages) in 2008. Among the remaining 8% of high schools, there was no pattern suggesting that the snack and beverage offerings were more or less healthful over time. There was a very substantial increase in the percentage of schools with a policy encouraging fruits and vegetables to be served at events and parties. This increased from 8% of schools in 2004 to 92% in 2008.

State mandated physical education (PE) policies, such as requiring PE for students and sports programs were offered in slightly more than half of high schools in 2008, a 10% decrease from the 2004 survey. The practice of exempting students from PE for school activities (clubs, band, other), community sports or another course was relatively uncommon in Utah high schools, but increased over the time period examined. Exemption from PE for participation in a school sport was reported 37% of high school principals in 2004 and by 54% principals in 2008. In 2008,

67% of schools allowed exemptions for at least one reason, but there was no pattern to which exemption a school allowed across the survey years. These results are shown in Figure 2.

By 2008 the majority of the 20 nutrition and physical activity topics were taught in health education classrooms at >90% of high schools (Figures 3 and 4). Within this group notable increases from 2004 to 2008 are reported in the proportion of health teachers providing instruction to 'increase student knowledge of nutrition' or to 'increase student knowledge of physical activity'. Physical activity application topics requiring more specific or personalized instruction, such as teaching adolescents to set up and monitor an individualized physical activity plan, were taught at the fewest schools in 2004 and 2008, with slight decreases reported over time.

Training and collaboration activities reportedly increased over the study period, as shown in Figure 5. Approximately half of health teachers reported they received nutrition or physical activity training in 2008, an increase from the 32% who received nutrition training and 39% who received physical activity training in 2004. Sixty-five percent of health teachers reported they would like training on both physical activity and nutrition yet 29% did not receive either type of training in the past year. Distinct patterns of training received and desired were not found, but were distributed across many schools. Collaboration between health teachers and physical education teachers was more common than collaboration between health teachers and food service staff (82% vs. 16%) in 2004 and in 2008 (84% vs. 26%). The minority of schools whose personnel reported no collaboration between health teachers and physical education teachers also reported no collaboration between health teachers and food service staff. Finally, school health advisory groups were established in 53% of high schools as of 2008, a reported increase from 42% in 2004.

Policy and Practices

Mandatory policy guidelines were not significantly related to school practices (Table 2). When practices were further grouped by domain (nutrition/food, physical activity/physical education, collaboration/training, school environment/classroom education) there were no significant

Figure 2. Proportion of High School Principals Reporting School Environment Practices, 2004, 2006 and 2008, n=66.

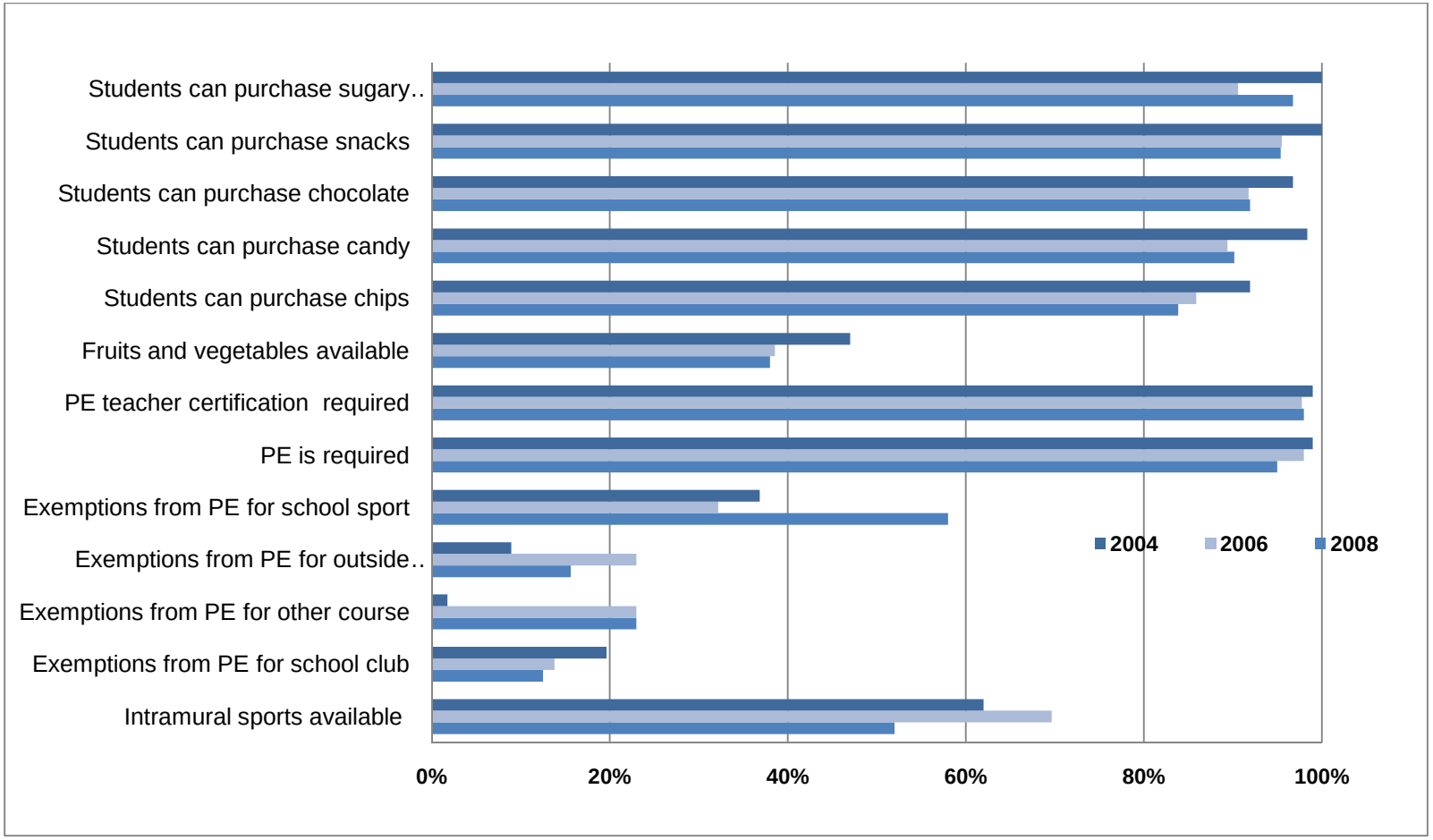
Students can purchase sugary..
Students can purchase snacks
Students can purchase chocolate
Students can purchase candy
Students can purchase chips
Fruits and vegetables available
PE teacher certification required
PE is required
Exemptions from PE for school sport
Exemptions from PE for outside..
Exemptions from PE for other course
Exemptions from PE for school club
Intramural sports available
2004
2006
2008
0%
20%
40%
60%
80%
100%

Figure 3. Proportion of Lead Health Education Teachers Reporting They Teach Nutrition Topics in Utah High Schools 2004, 2006 and 2008, n=57.

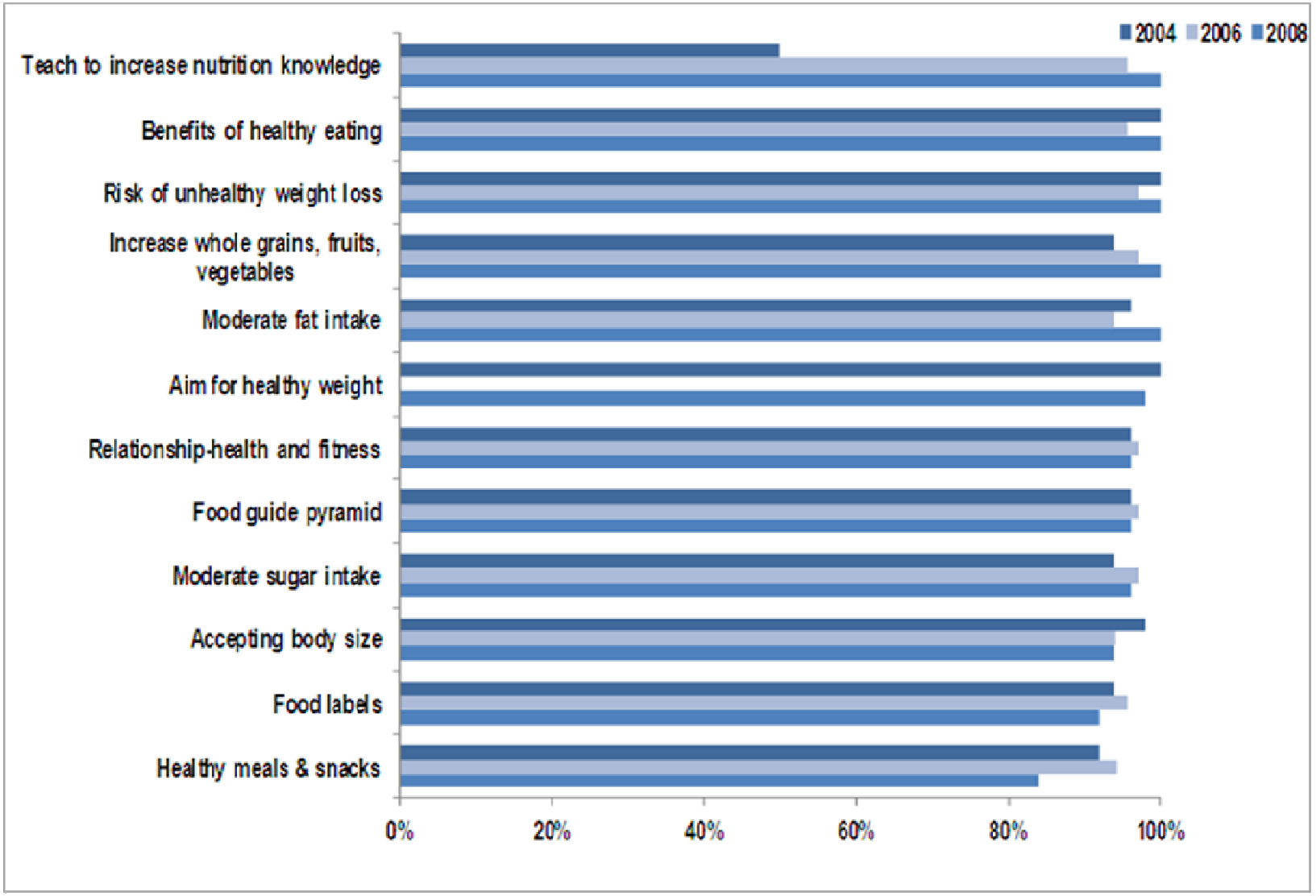
2004
2006
2008
Teach to increase nutrition knowledge
Benefits of healthy eating
Risk of unhealthy weight loss
Increase whole grains, fruits, vegetables
Moderate fat intake
Aim for healthy weight
Relationship-health and fitness
Food guide pyramid
Moderate sugar intake
Accepting body size
Food labels
Healthy meals & snacks
0%
20%
40%
60%
80%
100%

Figure 4. Proportion of Lead Health Education Teachers Reporting They Teach Physical Activity Topics in Utah High Schools 2004, 2006 and 2008, n=57.

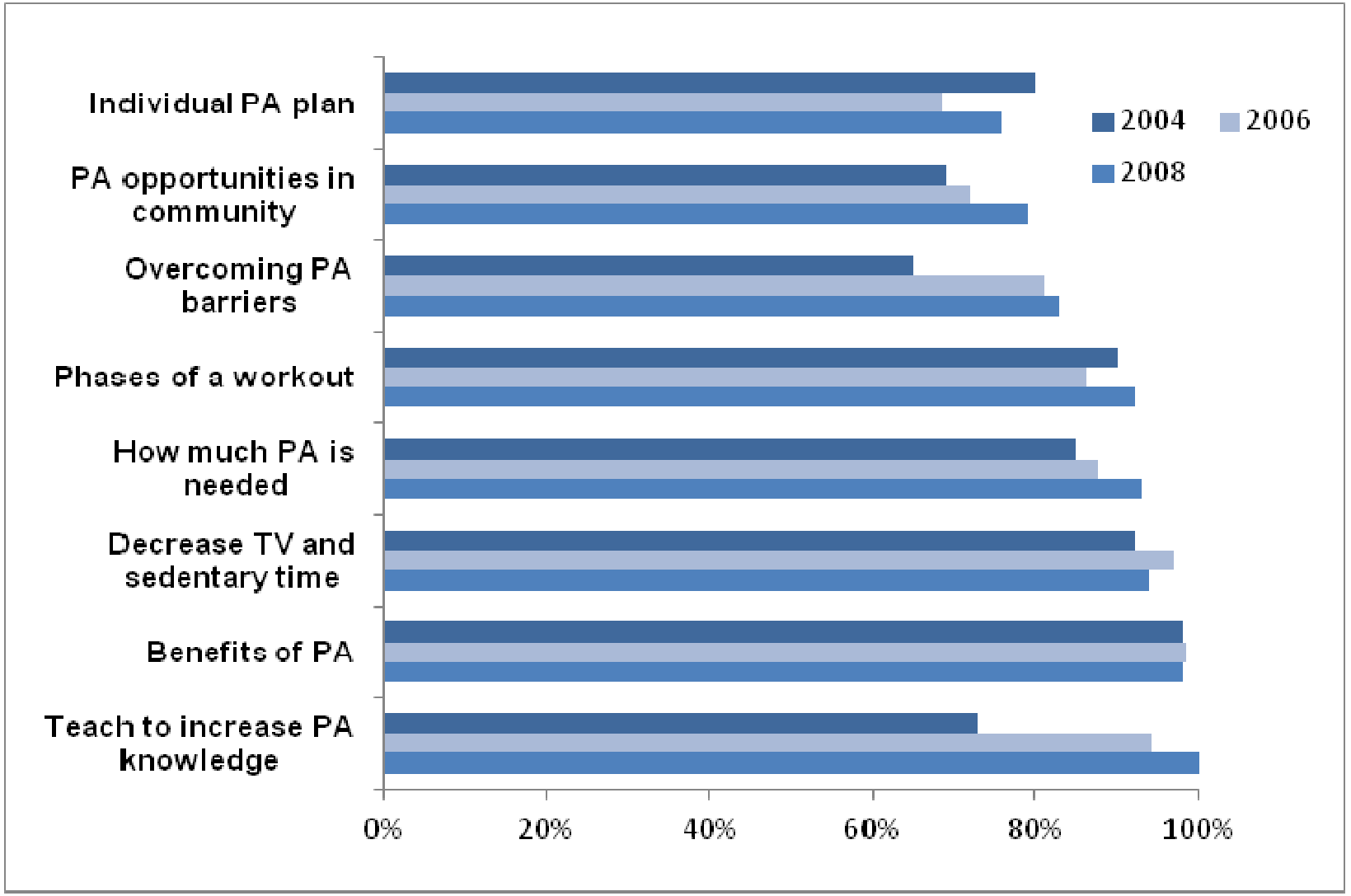
Individual PA plan
PA opportunities in community
Overcoming PA barriers
Phases of a workout
How much PA is needed
Decrease TV and sedentary time
Benefits of PA
Teach to increase PA knowledge
2004
2006
2008
0%
20%
40%
60%
80%
100%

Figure 5. Proportion of School Staff Reporting Obesity Related Collaboration or Training Practices in 2004, 2006 and 2008, n=57.

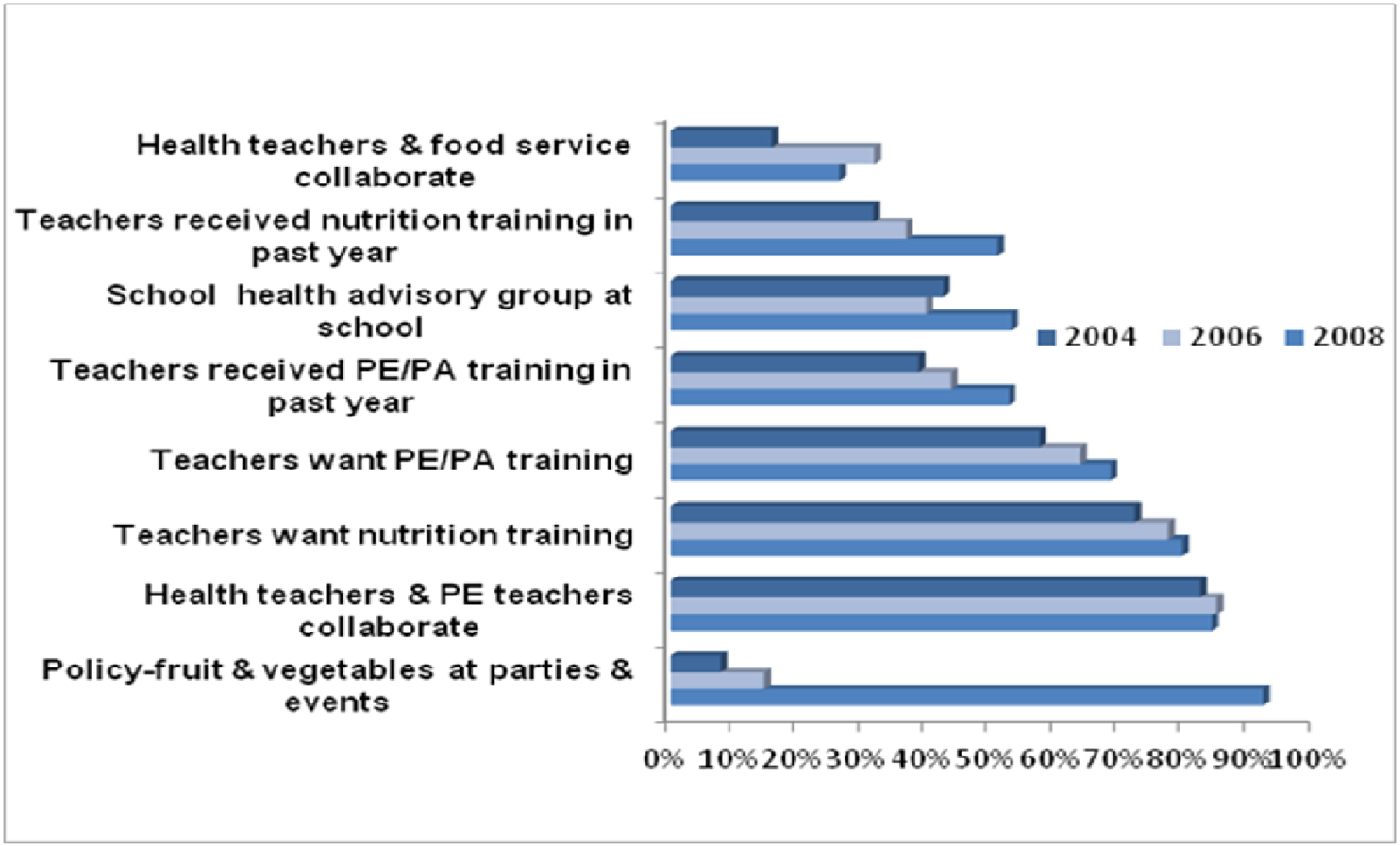
Health teachers & food service collaborate
Teachers received nutrition training in past year
School health advisory group at school
Teachers received PE/PA training in past year
Teachers want PE/PA training
Teachers want nutrition training
Health teachers & PE teachers collaborate
Policy-fruit & vegetables at parties & events
2004
2006
2008
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Table 2. Association of Selected High School Practices with School District Wellness Policy Guidelines, n= 66 Principal or 57 Health Teacher Responses.

Practice		**Policy**			**X^2**	**p-value**
Students can purchase candy		School district has a competitive foods policy guideline				
		Yes	No	Total	0.05	0.88
	Yes	43 (89.6%)	11 (91.7%)	54 (90%)		
	No	5 (10.4%)	1 (8.3%)	6 (10%)		
	Total	48 (100.0%)	12 (100.0%)	60 (100%)		
Intramural sports are available		School district has a PE policy guideline				
		Yes	No	Total	0.00	1.00
	Yes	20 (57.1%)	0	20 (57.1%)		
	No	15 (42.9%)	0	15 (42.9%)		
	Total	35 (100%)	0	35 (100%)		
Health teachers received PA training		School district has a staff wellness policy guideline				
		Yes	No	Total	1.74	0.19
	Yes	16 (44%)	12 (63.16%)	28 (50.9%)		
	No	20 (55.6%)	7 (36.8%)	27 (49.1%)		
	Total	36 (100%)	19 (34.6%)	55 (100%)		
School has a health advisory group		School district has plans for policy evaluation guideline				
		Yes	No	Total	0.78	0.38
	Yes	23 (51.1%)	12 (63.2%)	35 (54.7%)		
	No	22 (48.9%)	7 (36.8%)	29 (45.3%)		
	Total	45 (100%)	19 (100%)	64 (100%)		

School district wellness policy guideline was mandated vs. recommended or not present. Practices were reported as present or not present in the high school. Missing values occurred when school personnel did not respond to a *Profiles* question.

associations with policy guidelines. For school districts with more than 3 high schools in a district, comparisons were made at the high school level. There was no evidence that schools within the same district were more likely to report the same practices even though they were under the same district-wide policy. For example, when a competitive food guideline was mandated by the school district, schools within the same district were not more likely to restrict individual junk foods, beverages, or foods offered at celebrations or parties. Schools did not report similar school practices when their district policy included guidelines such as offering intramural sports, providing nutrition staff training, physical activity staff training or having a school health advisory committee.

Demographic and School Characteristics

Practices did not vary by school enrollment, rurality, race, and ethnicity or free and reduced lunch participation when analyzed individually or when grouped by domain (nutrition/food, physical activity/physical education, collaboration/training, school environment/classroom education).

Discussion

This study contributes to the limited evidence available on the implementation of the CNRA by examining changes in high school practices in one state. The research presented here suggests that high school personnel are reporting small changes in food offerings overall, but individual schools are not making comprehensive practice changes or responding to the competitive food policies written by their school district. An exception was the large increase in the number of schools reporting a policy that fruits and vegetables are offered at parties and celebrations. This was reported by <10% of principals in 2004 and >90% in 2008. Specific attention was given to this topic in wellness templates produced by the School Nutrition Association[39] and Action for Healthy Kids[40] and presented at state trainings. Policy guidelines that address an issue that has room for improvement and are concrete in terms of expectations may be most successful.

Most schools (67%) allowed students to be exempt from a required physical education course for at least one reason. PE exemptions showed a trend that is counter to the wellness initiative. Principals may be lax in enforcing PE requirements due to budget constraints or pressures to improve academic test scores.[41] The two physical education practices that are monitored by the state education policy, certification of physical education instructors and a requirement for every student to take a physical education course, were reported by all but two schools.

The ability of state policy to influence change more effectively than a district policy even when it is mandated nationally is noted in the competitive foods literature. Kubik et al looked at 538 school districts and 1,103 schools in the nation and noted no changes in school junk food availability based on school district policy, whereas state policy predicted less availability of junk food and beverages.[20] Similarly, schools may be more familiar with or responsive to state physical education policy. Others have noted that physical activity may not receive adequate attention in wellness policy efforts. Since the CNRA is a reauthorization of nutrition programs, the focus on physical activity may not be well communicated to school administrators.[16,28]

The results for topics covered in health education courses found in this study are consistent with CDC *Profiles* reports. In 2008, information for Utah indicates that each nutrition and physical activity topic was taught by 89-98% of health education teachers.[42] Utah high schools have a health education course requirement, assuring that every student is exposed to basic knowledge on the importance of healthy weight for current and future health. The wellness policy initiative may serve to reinforce the importance of teaching nutrition and physical activity concepts in high school.

Results provide evidence that staff development and training related to nutrition and physical fitness increased from 2004-2008. A previous report notes that in 2004, 21.4% of Utah health education teachers received staff development on nutrition and dietary behavior and 34.9% received staff development on physical activity and fitness.[42] The study reported here indicates a notable increase in 2008 with 51% and 53%, respectively, reporting nutrition and

physical education training. The increase in staff development in these areas may indicate support for obesity prevention that has yet to translate beyond the classroom.

Broad support from school personnel is needed for school environment changes.[43] In this study, collaboration between physical activity instructors and health teachers is an established practice, while collaboration between health teachers and food service personnel is uncommon. This suggests further opportunity for teachers to use school cafeteria facilities as a laboratory for applied learning and to use the expertise of food service personnel when addressing nutrition in the classroom. Additionally, with just over half of schools indicating the presence of a school health advisory group, there is opportunity to promote collaborative working groups in high schools to address the many health needs of adolescents, including obesity prevention.

The finding that practices did not vary by participation in the free and reduced price meal program is contrary to the policy literature. Prior examination in Utah found that policy tenets were more likely to be mandated in districts with high free and reduced price meal participation.[29] Researchers in Georgia report that school districts with higher economic profiles are more likely to have mandated policies.[44] Nationally, principals of secondary schools with a higher percentage of students receiving free and reduced price meals are reported to have less knowledge of the school wellness initiative.[16] It is important to examine differences in implementation and address disparities. An increase in the prevalence of obesity has been noted among all socioeconomic classifications[45] suggesting universal implementation is appropriate. However, the relationship of obesity and economic status is complex and differs by race, ethnicity and gender. It is critical to assure that adolescents with increased risk of obesity are exposed to healthful school environments and obesity prevention messages.[35]

Three directions are suggested by the results. Schools, particularly high schools, may be best suited to address obesity prevention in the health education classroom. Results demonstrate that nutrition and physical activity topics are covered consistently over time in required courses. In this case, priority should be given to teacher training and education, especially for topics that require explanation and application beyond didactic information.

Secondly, schools require concrete guidelines and additional resources for implementing policy requirements that go beyond the classroom. The 2010 CNRA—the Healthy, Hunger Free Kids Act—to be implemented in 2012, will include guidance on competitive foods, additional emphasis on implementation, and will require environmental reports describing school progress. Thirdly, methods to assess wellness policy implementation that extend beyond survey tools such as *Profiles* and demonstrate external validity are needed to fully capture the outcomes of school policy approaches.

Strengths and Limitations

This study adds to the scarce literature on high school practices resulting from the 2004 CNRA and also examines high school practice patterns in relationship to district wellness policy content. To the authors' knowledge, this is the first such examination at the state level.

Since *Profiles* information is available on Utah high schools every 2 years, it was possible to examine practices pre and post the CNRA deadline without lag time. Additionally, changes could be examined over time. The responses for the same schools over multiple time periods suggest the overall percentage changes are misleading. For example, the number of schools offering high fat chips in competitive food venues decreased (92% to 84%, $p<0.07$) from 2004-2008. There were 57 schools reporting this practice in 2004. Nine schools stopped offering high fat chips in 2008, but 4 schools started, for a net change of 5 schools. The change in the number of schools reporting that health teachers received PA training was significant (39% to 53% of schools, $p<0.04$). However this represented 24 schools that reported the practice in 2004 with 12 continuing the practice in 2008, 12 discontinuing the practice and 22 schools starting the practice. Similarly, the number of schools with school health advisory committees increased from 28 to 35 schools. Of the 28 schools reporting the practice in 2004, 13 discontinued the practice and 20 schools began the practice.

Despite strengths, there are two key limitations to this study. It is possible that *Profiles* does not capture what is necessary to evaluate the school environment in light of the wellness policy legislation. The survey questions require a yes or no response. Detailed information quantifying how often, in what manner, and to what extent practices are implemented is needed.

This study does not include information about the foods provided in the school cafeteria, a significant part of the school wellness environment. Further, it is possible that the individuals completing the *Profiles* survey may not be the school personnel most familiar with school practices. This may be particularly true for practices outside the classroom, which are reported by the school principal. It has been reported that food service personnel are the most reliable in reporting the competitive foods available.[46] Physical education teachers may have a better knowledge of daily physical activity practices and exemptions. Additionally, this analysis was conducted in one state, which limits the ability to generalize results beyond the Western United States.

Conclusion

Schools are logical sites for prevention. The intention of the national school wellness policy is to encourage high schools to adopt practices that prioritize physical activity, provide a school environment supportive of healthful eating, and address obesity prevention concepts in health courses. Addressing these issues at school is seen as one component of a comprehensive approach to obesity prevention including efforts to influence adolescent behavior in health care, the community and at home.

The results do not provide evidence of a substantial change in practices in the 2 years following the federal mandate. In addition there were no strong associations between the specific policy of the school district and the practices reported by the schools in that district. For many of the items, practices were in common use before the mandate was established. This analysis does not indicate that practices in Utah high schools changed or that high schools adopted practices in line with their districts' wellness policies.

Results of the research presented here should be useful to those implementing the 2010 CNRA starting in 2012. When policies are revised, they should be specific in their requirements for school implementation. The finding that it is difficult to change high school practices, despite school district wellness policies, suggests that school personnel, community members and public health professionals should focus on secondary schools when setting resource priorities within a district or state. Finally, in the immediate future, methods to examine the implementation of

school wellness policies are needed. Research is necessary to determine if the additional requirements in the 2010 CNRA influence the implementation of school wellness policy tenets, especially in high schools.

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CHAPTER 3

A MULTIVARIATE ANALYSIS OF SCHOOL WELLNESS PRACTICES ON ADOLESCENT OBESITY

Abstract

PURPOSE: To assess the association of school wellness practices with adolescent overweight and obesity while controlling for individual, family and school characteristics.

METHODS: School nutrition and physical activity practices were obtained from the 2004, 2006 and 2008 School Health Profiles surveys. Adolescent and family attributes were obtained from the Utah Population Database (UPDB). School characteristics were accessed via the Common Core of Data. Bivariate and multinomial analyses were performed to model the relationship of school practices with adolescent overweight and obesity.

RESULTS: Of the 42 school practices examined, only exempting students from PE was associated with the risk of obesity (RR_a=0.76,95% CI: 1.16-1.74, p<0.02). Individual, family and school attributes were significantly associated with high BMI. Maternal obesity tripled the risk adolescent overweight (RR_a=3.08, 95% CI: 2.54-3.76, p<0.001) and resulted in a six-fold risk of obesity (RR_a=6.06, 95% CI: 4.988-7.52, p<0.001). American Indian adolescents had twice the risk of obesity (RR_a= 2.09, 95% CI: 0.91-4.80, p <0.01) and Black adolescents had almost four times the risk of overweight when compared to White adolescents (RR_a=3.80, 95% CI: 1.37-10.48, p<0.01). When the population of a high school was >70% -White, the risk of adolescent obesity was greater than in a less diverse school (RR_a=1.43, 95% CI: 1.16-1.74, p<0.01). School practices were not related to their district having a mandatory policy related to that practice.

CONCLUSION: Overall, the implementation of nutrition and physical activity practices in high schools was not associated with adolescent overweight or obesity in Utah. Research is needed to develop tools that quantify wellness policy efforts. School wellness efforts should incorporate family involvement and prioritize high risk populations.

Introduction

The prevalence of high body mass index (BMI) among adolescents has remained steady for 10 years.[1] In the United States, 18.1% of adolescents are obese and 34.2% are overweight or obese.[2] Along with the prenatal and preschool life-stages, adolescence is one of three critical periods in the development of obesity during childhood.[3] Obesity in adolescence is the single best predictor of adult obesity.[4-6] It is estimated there will be an additional 65 million obese adults in the United States by 2030.[7] Youth obesity prevention is posited as a viable strategy for slowing this trend.[8]

In 2005, the Institute of Medicine developed an action plan for child and adolescent obesity prevention.[9] The school and home environments were identified as key sites for prevention efforts. At school, children are exposed to food choices, options for physical activity and health education courses. In the home, parents model dietary and physical activity habits before and during adolescence.[10,11]

The Child Nutrition and WIC Reauthorization Act of 2004 (CNRA) was the most comprehensive national strategy to address obesity prevention in schools.[12] The CNRA required school districts to develop written wellness polices that address goals for nutrition education, physical activity, foods sold at school and other school based wellness activities. School districts were required to involve a diverse group of stakeholders in development of the policy. Plans for monitoring and evaluation were to be written as part of the wellness policy.[12] This legislation provided a unique opportunity to determine whether alterations in the school environment are associated with the prevalence of overweight and obesity.

Evaluation of the school wellness policy effort is in its infancy. National and state reports indicate moderate to high levels of compliance with the written policy requirements of the CNRA.[13] School wellness policy content is more comprehensive among school districts with

stronger academic performance and lower proportions of economically disadvantaged students.[6] School districts are hesitant to write forceful guidelines that mandate implementation of the policies.[14] The prevalence of adolescent and obesity has been shown to be lower, however, in communities where school districts mandate wellness policy guidelines when compared to communities that have weak recommendations or no policy guidelines.[15]

Few studies have examined implementation of school wellness policy tenets. Three studies reported modest improvements in competitive food availability or sales in elementary and secondary schools.[11,14,16] A recent national report using data from the School Health Policies and Practices Survey (SHPPS) examined cafeteria, competitive foods and physical activity practices in high schools post wellness policy.[17] The proportion of students exposed to healthful nutrition and physical activity practices varied from 8% of those who attended a school where physical fitness testing was conducted to 88% enrolled in a school that does not offer french fries every day. The authors concluded that pizza, french fries, sugar-sweetened beverages and candy were widely accessible to high school students. The report further notes that physical activity practices are “especially lax”. To date, no studies have been conducted that assess health outcomes associated with school wellness policy implementation.

In the home, parental obesity conveys risk for adolescent obesity.[18] Eating patterns and sedentary behaviors cluster in families.[19] Food availability in the home influences the overall intake of milk, fruit, vegetables and soft drinks during adolescence.[20] Parental support for physical activity and sibling participation in physical activity are correlates of adolescent physical activity.[21] Programs that include family involvement have the ability to address parenting issues, family dynamics or socioeconomic issues that are barriers to obesity prevention.[22]

As both the school and family environments may influence eating and physical activity behaviors, the effect of school policy cannot be assessed without considering the family environment. The objective of this study was to assess the association of school wellness practices with adolescent overweight and obesity while controlling for individual, family and school characteristics. It was hypothesized that adolescents living within the boundaries of high

schools reporting nutrition and physical activity practices would have a lower relative risk of overweight and obesity.

Methods

Inclusion and exclusion criteria are described in Figure 6. Adolescent BMI was calculated from the self-reported height and weight as recorded on the Utah driver's license. Driver's license data was obtained from the Utah Population Database (UPDB) a compilation of genealogic and administrative records of Utah residents. Weight categories were defined at 3 levels: less than the 85th percentile for age, at or above the 85th percentile for age and at or above the 95th percentile for age according to guidelines from the Centers for Disease Control and Prevention.[24] Levels were labeled "not overweight or obese," "overweight" and "obese."

The student's sex, race, and ethnicity were obtained from driver's license data. Since the early 1980s, the UPDB has linked 79% of the driver's license data to the child's birth certificate. This linkage provided information on maternal race and ethnicity, maternal education and maternal BMI for each adolescent.

Maternal education was categorized as <12 years (less than high school), 12-13.9 years (high school), 14-16 years (associate or bachelor's degree) and >16 years (beyond bachelor's degree). Maternal BMI was classified according to the Centers for Disease Control and Prevention (CDC) standards for adults. Categories included normal weight/underweight <25.0 kg/m^2, overweight $\geq$25.0 and <30.0 kg/m^2 and obese $\geq$30 kg/m^2.[24]

The School Health Profiles (*Profiles*) for Utah was used to assess the wellness practices of high schools.[25] *Profiles* is a biennial survey that includes two questionnaires: one for principals or their designate and one for the lead health teacher. Items regarding the presence or absence of nutrition, food, and physical activity physical education practices were selected for the analysis. This included 13 school practices affecting the school environment, 21 health education practices and 8 staff training and collaboration practices. These practices were generally congruent with the guidelines outlined in the Child Nutrition Reauthorization Act of 2004 (CNRA)[11] School

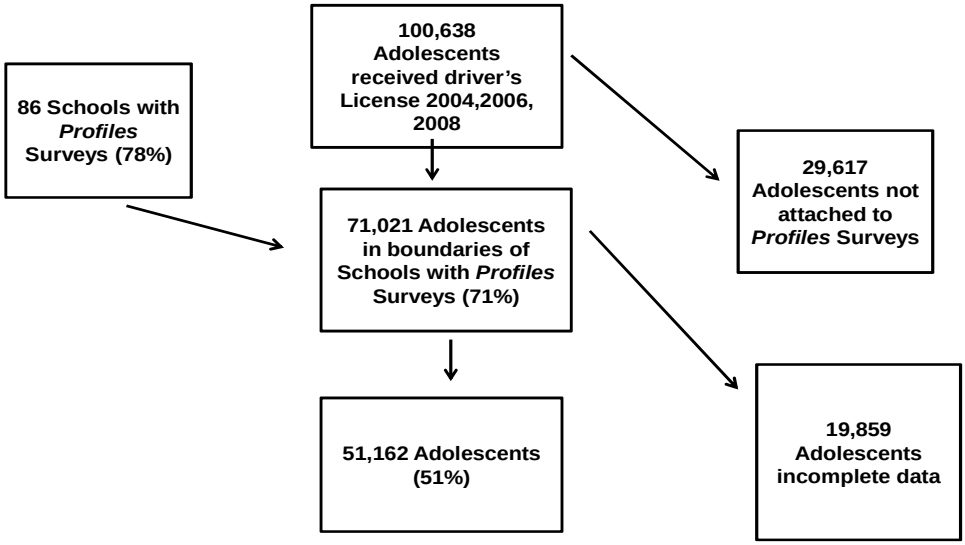

Figure 6. Inclusion and Exclusion Criteria.

characteristics were appended from the Common Core of Data (CCD) for the 2007-08 school years. The CCD is an annual compilation of demographic data from each school in the United States collected by the Department of Education.[26] School characteristics included total student enrollment, race and ethnicity of students, free and reduced price meal eligibility and rural/urban location of the school. A seasonal variable was created to assess differences by school year (September-May) versus summer break (June-August).

Each adolescent was linked to their high school based on the address listed on their driver's license. School boundary maps, obtained from each school district website, were used to create a geo-referenced data layer using ArcGIS© (version 9.3)[27]. The addresses were geo-coded and spatially joined to the school boundary data to identify the individual's high school.

Each geo-coded student was then linked to the results of the Profiles survey based on school and the year they received their license (e.g., students who received their license between September 1, 2006 and August 31, 2007 were linked to the 2006 Profiles data). Students whose school did not participate in *Profiles* for the time period they received their driver's license were not included, resulting in a final sample of 51,162 Utah adolescents.

Statistical Analysis

Bivariate analyses were performed to investigate the relationship of each covariate with BMI status by regressing each covariate individually against the categorical BMI variable using a multinomial logistic regression. Multinomial logistic regression allowed BMI to be characterized by three mutually exclusive groups that carry different implications in public health.

Multinomial logistic regression was also used to estimate the probability of being overweight or obese versus normal weight according to school practices, controlling for individual, family, and school characteristics. The Huber-White modified sandwich estimator was utilized to adjust for the nonindependence bias that may occur given that adolescent observations are nested within schools. Chi-square tests were used to identify practices which were highly related, and only one of the related practices was used in the model. This produced a final set of independent practice variables. Each regression started with a fully-specified model. Covariates which were nonsignificant were removed, and the effect on the other parameter estimates was

noted. Analyses were performed using STATA 10.1 Intercooled©.[28] This research was approved by the University of Utah Institutional Review Board, project number 0024209.

Results

Table 3 shows sample characteristics and the distribution of BMI by individual and school covariates. A greater proportion of females than males were at a healthy BMI (87.7% vs. 80.2%, p <0.01). Overweight and obesity prevalence also varied by race and ethnicity with a much higher proportion of Black, American Indian and Polynesian adolescents being either overweight or obese. The prevalence of obesity among Hispanics was almost double that of non-Hispanics (11.5% vs. 6.2%, p<0.01).

Mother's BMI was related to the BMI of their child; when a mother was overweight, the proportion of overweight adolescents was 15.3% compared to 8.8% when the mother was not overweight or obese (p<0.01). Overweight and obesity were inversely related to the mother's education with 8.1% overweight when the mother had education beyond a bachelor's degree. When the mother did not complete high school, 13.2% of adolescents were overweight (p<0.01).

There were a larger proportion of overweight and obese adolescents when school enrollment was diverse in race and ethnicity. When Hispanic adolescents comprised >30% of school enrollment, the proportion of adolescents who were obese increased by 5 percentage points. In schools with <15% participation in the free and reduced price meal program, the proportion of teens at a healthful weight was 84.8% versus 78.9% when participation rates were >50% (p<0.01). The proportion of adolescents in each BMI classification was similar by geographic locale, school enrollment and season.

Table 4 describes the bivariate associations of school wellness practices and BMI categories. Many of the wellness practices were related to the risk of being overweight or obese. When schools had fruits and vegetables available in vending machines, school stores or canteens, the relative risk of overweight or obesity was 0.86 (95%CI: 0.08-0.92, p<0.001). When this practice was present, the relative risk of obesity was 0.81 (95% CI: 0.73-0.90, p<0.001) compared to normal weight students. Risk for both overweight and obesity was lower when

Table 3. Sample Attributes by Body Mass Index (not overweight, overweight, obese), n=51,162.

		Body Mass Index		
		Not Overweight n= 42,858 83.77%	Overweight n=5,045 9.86%	Obese n=3,259 6.37%
Sex	%	%	%	%
Female	47.45	87.72	8.57	3.70
Male	52.55	80.19	11.03	8.77
Race				
Black	0.24	68.75	16.96	14.29
American Indian	0.57	65.56	16.18	18.26
Pacific Islander	1.24	71.46	14.68	13.86
Asian	0.44	86.07	7.46	6.47
White	97.4	84.06	9.76	6.18
Other/Unknown	0.1	82.39	9.66	7.95
Ethnicity				
Hispanic	4.06	75.02	13.50	11.48
Non-Hispanic	95.94	84.14	9.71	6.15
Age				
15	4.54	84.15	10.00	5.85
16	72.83	84.32	9.65	6.03
17	15.72	81.33	10.65	8.00
18	6.90	82.01	10.04	7.94
Mother's Education				
<12 years	9.69	76.88	13.23	9.90
12-14 years	36.82	82.10	10.68	7.22
15-16 years	34.81	85.46	8.99	5.54
>16 years	18.68	87.49	8.13	4.38
Mother's BMI Category				
Not overweight	8.67	86.75	8.80	4.45
Overweight	65.19	74.68	15.27	10.05
Obese	17.17	82.81	10.48	6.71
Mother's Age				
<25 years old	33.08	82.54	10.56	6.90
>25 years old	66.92	84.26	9.52	6.22
Mother's Marital Status				
Married	92.84	84.37	9.57	6.11
Not married	7.16	75.52	13.70	10.78
Geographic Locale				
Rural	13.23	82.54	10.50	6.97
Urban	86.77	83.95	9.77	6.28

Table 3 continued

		Body Mass Index		
		Not Overweight n= 42,858 83.77%	Overweight n=5,045 9.86%	Obese n=3,259 6.37%
School Enrollment				
<500	38.90	83.98	9.78	6.25
500-1200	9.64	82.45	10.51	7.03
1201-2000	33.96	83.61	9.86	6.53
>2000	17.50	84.32	9.71	5.97
Season				
School year	73.03	74.99	75.05	75.05
Summer break	24.97	25.01	24.95	24.95
Free and reduced price meal eligibility				
<15% of students	53.67	84.79	9.00	5.79
15-29% of students	33.62	83.01	10.18	6.82
30-50% of students	8.17	82.66	10.31	6.83
>50% of students	4.54	78.98	11.90	9.12
Race/ethnicity of student population				
>70% -White or Hispanic		77.51	12.71	9.78
Yes	26.11	86.03	8.82	5.15
No	73.89			
>5% Black				
Yes	5.74	77.90	12.84	9.26
No	94.26	84.16	9.66	6.18
>30% Hispanic				
Yes	21.08	76.44	13.16	10.40
No	78.92	85.77	8.95	5.28

Adolescent sex, age, race, ethnicity, height and weight were obtained from the first state issued driver's license. Mother's prepregnancy BMI, marital status and age were obtained from the child's birth certificate. School enrollment and free or reduced price meal eligibility were obtained from the National Center for Education Statistics Common Core of Data. School wellness practices were obtained from the Utah School Health Profiles.

Table 4. Bivariate Association of School Practices and Body Mass Index (not overweight, overweight, obese), n=51,162.

School Practices		**Body Mass index**			**Unadjusted RR (CI)**			
		Not overweight	Overweight	Obese	Overweight		Obese	
School Environment		%	%	%	RR (CI)	p-value	RR (CI)	p-value
Students can purchase fruit and vegetables								
	Yes	83.10	10.22	6.68	0.86 (0.08-0.92)	0.001	0.81 (0.73-0.90)	0.001
	No	84.50	9.57	5.93	1.0		1.0	
Students can be exempt from PE for…								
school sport	Yes	84.18	9.55	6.26	0.91 (0.85-0.97)	0.001	0.90 (0.81-0.99)	0.04
	No	82.35	10.31	7.34	1.0		1.0	
another class	Yes				1.12 (1.03-1.21)	0.001	1.15 (1.01-1.31)	0.03
	No				1.0		1.0	
Intramural sports available								
	Yes	83.22	10.30	6.48	0.86 (0.81-0.93)	0.001	0.83 (0.75-0.92)	0.001
	No	83.71	9.89	6.40	1.0		1.0	
Health Education Topics								
Healthy meals and snacks								
	Yes	83.48	10.10	6.41	1.06 (0.95-1.18)	0.54	1.06 (0.89-1.23)	0.50
	No	83.98	9.75	6.31	1.0		1.0	
How to monitor your PA								
	Yes	83.32	10.18	6.51	0.88 (0.83-0.95)	0.001	0.94 (0.82-1.08)	0.39
	No	84.48	9.69	5.83	1.0		1.0	
Staff Training								
Teachers collaborate with food service personnel								
	Yes	83.00	10.17	6.82	0.93 (0.83-1.02)	0.15	0.94 (0.82-1.08)	0.39
	No	83.55	10.12	6.33	1.0		1.0	

Table 4 continued

School Practices		**Body Mass index**			**Unadjusted RR (CI)**			
		Not overweight	Overweight	Obese	Overweight		Obese	
		%	%	%	RR (CI)	p-value	RR (CI)	p-value
Teachers received nutrition training in past year	No	83.66	9.88	6.26	1.0		1.0	
	Yes	84.00	10.00	6.00	0.92 (0.8600.98)	0.15	0.92 (0.83-1.03)	0.39
	No	83.60	9.88	6.26	1.0		1.0	

School practices were obtained from the 2004, 2006 and 2008 School Health Profiles and assigned to each adolescent by school boundary. Adolescent height and weight was obtained from the first state issued driver's license or permit.

schools provided intramural sports. In the presence of this practice, the relative risk of overweight was 0.86 (95%CI: 0.81-0.93, p=0.001) and the relative risk of obesity was 0.83 (95%CI: 0.75-0.92, p<0.001) compared to normal weight students. When students were allowed exemption from PE for a school sport, the relative risk of overweight was 0.91 (95% CI: 0.85-0.97, p=0.001) and the relative risk for obesity was 0.90 (95% CI: 0.81-0.99, p=0.04) when compared to normal weight students.

While some of the classroom practices were associated with BMI, many were not. Education on "monitoring individual physical activity plans" was protective for overweight (RR_a=0.88, 95%CI: 0.83-0.95, p<0.00) but had no effect on obesity risk at 0.91 (95% CI: 0.67-1.03, p<0.08). Teaching about healthy meals and snacks was not related to the risk of overweight or obesity. No significant differences in the risk of overweight and obesity were found when schools reported nutrition training, collaboration between health teachers and food service personnel or the presence of a school health advisory group.

Table 5 shows the results of multinomial logistic regression using "not overweight or obese" as the reference category. In the final model, high maternal BMI had the greatest effect on the relative risk of adolescent overweight and obesity among the covariates. The relative risk of adolescent overweight was 1.95 (95% CI: 1.65-2.29, p<0.001) and relative risk of obesity was 2.65 (95% CI: 2.17-3.24, p<0.001) when the mother was overweight. Adolescent relative risk of overweight was 3.08 (95% CI: 2.54-3.76, p<0.001) and the relative risk of obesity was 6.06 (95% CI: 4.88-7.52, p= 0.001) when the mother was obese.

Several other individual and family attributes were associated with BMI category. Adolescent males had 1.41 (95% CI: 1.23-1.62, p<0.001) the relative risk of overweight and 2.23 (95% CI: 1.87-2.66, p<0.001) the risk of obesity compared to females. Black adolescents had a considerably higher relative risk of overweight (RR_a=3.80 95% CI:1.37-10.48, p<0.01) when compared to White adolescents. American Indian and Pacific Island adolescents had approximately double the risk of obesity when compared to White adolescents. Relative risk of

Table 5. Risk Ratios (RR) and 95% Confidence Intervals (CI) from Multinomial Regressions of the Likelihood of Being Overweight or Obese by Individual Attributes, Family Attributes, School Characteristics and School Wellness Practices, n= 51,162.

	Unadjusted RR (CI)				Adjusted (CI)			
	Overweight	p-value	Obese	p-value	Overweight	p-value-	Obese	p-value
Exemptions from PE for another class								
Yes	1.12 (1.031.21)	0.001	1.15 (1.01-1.31)	0.03	0.87 (0.73-1.03)	0.11	0.76 (0.6-0.95)	0.02
No	1.0		1.0		1.0		1.0	
Sex								
Female	1.0		1.0		1.0		1.0	
Male	1.77 (1.71-1.85)	0.001	2.64 (2.46-2.82)	0.001	1.41 (1.23-1.62)	0.001	2.23 (1.87-2.66)	0.001
Race								
White	1.0		1.0		1.0		1.0	
Black	2.62 (1.88-3.63)	0.001	3.12 (2.06-4.73)	0.001	3.80 (1.37-10.48)	0.01	3.03 (0.82-1.19)	0.57
American Indian	3.23 (2.71-3.84)	0.001	3.87 (3.12-4.79)	0.001	1.73 (0.80-3.74)	0.16	2.09 (0.91-4.80)	0.02
Pacific Islander	2.38 (2.09-2.72)	0.001	2.38 (2.09-2.72)	0.001	2.67 (2.25-3.17)	0.001	1.51 (0.99-2.30)	0.001
Ethnicity								
Hispanic	1.76 (1.61-1.95)	0.001	1.86 (1.67-2.06)	0.001	1.29 (0.96-1.72)	0.09	1.47 (1.05-2.06)	0.03
Non-Hispanic	1.0							
Age	1.03 (1.01-1.04)	0.001	1.07 (1.05-1.09)	0.001	0.94 (0.83-1.06)	0.32	0.99 (0.85-1.13)	0.84
Mother's Education								
<12 years	1.33 (1.27-1.39)	0.001	1.47 (1.31-1.55)	0.001	1.24 (0.98-1.58)	0.06	1.40 (0.99-1.77)	0.02
12-14 years	1.0		1.0		1.0		1.0	
15-16 years	0.81 (0.78-0.84)	0.001	0.75 (0.72-0.78)	0.001	0.94 (0.80-1.10)	0.43	0.83 (0.68-1.01)	0.08
>16 years	0.71 (0.68-0.74)	0.001	0.57 (0.54-0.61)	0.001	0.85 (0.6901.04)	0.11	0.74 (0.57-0.96)	0.02
Mothers' BMI category								
Not overweight	1.0		1.0		1.0		1.0	
Overweight	2.22 (2.04-2.34)	0.001	2.40 (2.21-2.62)	0.001	1.95 (1.65-2.29)	0.001	2.65 (2.17-3.24)	0.001
Obese	4.51 (4.23-4.82)	0.001	5.97 (5.48-6.40)	0.001	3.08 (2.54-3.76)	0.001	6.06 (4.88-7.52)	0.001
Mother Married								

Table 5 continued

	Unadjusted RR (CI)				Adjusted RR (CI)			
	Overweight	p-value	Obese	p-value	Overweight	p-value	Obese	p-value
Yes	0.63 (0.59-0.67)	0.001	0.51 (0.48-0.54)	0.001	o.81 (0.63-1.05)	0.11	0.77 (0.57-1.04)	0.09
No	1.0		1.0		1.0		1.0	
Mother's Age								
<25 years	1.0	0.001	1.0		1.0		1.0	
≥25 years	0.88 (0.85-0.91)	0.001	0.88 (0.850.92)	0.001	0.81 (0.69-0.95)	0.01	0.81 (0.67-0.99)	0.37
Season								
School year	1.0		1.0		1.0		1.0	
Summer break	0.97 (0.89-1.04)	0.037	1.07 (0.95-1.12)		0.88 (0.76-1.02)	0.88	1.00 (0.83-1.22)	0.12
School enrollment								
<500	1.0		1.0		1.0		1.0	
500-1200	1.10 (1.04-1.17)	0.001	1.09 (0.98-1.19)	0.001	1.08 (0.68-1.72)	0.74	0.94 (0.55-1.61)	0.82
1201-2000	1.12 (1.06-1.17)	0.001	1.17 (1.09-1.26)	0.001	1.19 (0.94-1.49)	0.15	0.92 (0.68-1.23)	0.56
>2000	0.85 (0.80-0.90)	0.001	0.82 (0.74-0.90)	0.001	1.06 (0.87-1.30)	0.57	0.96 (0.74-1.30)	0.77
Free and reduced price meal eligibility								
<15%	1.0		1.0		1.0		1.0	
15-29%	1.31 (1.2501.37)	0.001	1.42 (1.33-1.52)	0.001	1.05 (0.86-1.29)	0.62	1.51 (1.16-1.95)	0.001
30-50%	1.30 (1.21-1.40)	0.001	1.43 (1.28-1.60)	0.001	1.06 (0.69-1.60)	0.70	1.28 (0.76-2.16)	0.35
>50%	1.60 (1.46-1.74)	0.001	1.64 (1.44-1.87)	0.001	1.17 (0.82-1.68)	0.37	1.02 (0.67-1.56)	0.91
School race/ ethnicity								
>70% -White or Hispanic								
Yes	1.55 (1.49-1.62)	0.001	2.05 (1.95-2.15)	0.001	1.15 (0.83-1.59)	0.39	1.43 (1.16-1.74)	0.01
No	1.0		1.0		1.0		1.0	
>5% Black								
Yes	1.42 ((1.31-1.54)	0.001	1.58 (1.43-1.73)	0.001	0.83 (0.55-1.24)	0.36	1.23 (0.83-1.96)	0.26
No	1.0		1.0		1.0		1.0	
>30% Hispanic								
Yes	1.60 (1.54-1.68)	0.001	1.96 (2.85-3.10)	0.001	1.16 (0.83-1.61)	0.39	1.31 (0.88-1.94)	0.18

Table 5 continued

	Unadjusted RR (CI)				Adjusted RR (CI)			
	Overweight	p-value	Obese	p-value	Overweight	p-value	Obese	p-value
No	1.0		1.0		1.0		1.0	

Mother's prepregnancy BMI, education level, marital status and age obtained from the child's birth certificate. School characteristics obtained from the Common Core of Data. School practices obtained from the Utah School Health Profiles Survey.

obesity was associated with the mother's education. When maternal education was less than high school, the relative risk of obesity was 1.40 (95% CI: 0.99-1.77, p<0.02). Relative risk of obesity was 0.74 (95% CI: 0.57-0.96, p<0.02) when maternal education extended beyond a bachelor's degree.

Certain school practices and characteristics were significantly associated with obesity, but not overweight. The only school practice that remained significant in the final model was "allowing exemption from PE for another class." The relative risk of adolescent obesity for this practice was 0.76 (95% CI: 0.61-0.95, p<0.02). This practice was not associated with overweight. When free and reduced price lunch participation was <15%, the relative risk of obesity was 1.51 (95% CI: 1.16-1.95, p<0.001) and the risk for overweight was not significant. The relative risk of obesity was greater when the composition of school enrollment was >70% -White or Hispanic. The relative risk of adolescent obesity was 1.43 (95% CI: 1.16-1.74, p<0.001) when this characteristic was present, but it was not associated with overweight. There was no difference in the relative risk of overweight or obesity when school was in session versus summer break. The relative risk of overweight and obesity did not vary by rurality.

Discussion

Individual and Family Attributes

This study found rates of overweight and obesity similar to the Utah Youth Risk Behavior Survey (YRBS).[29] Twenty-one percent of adolescents were classified as overweight in the YRBS, compared to 19.6% in the current study. The YRBS classifies 12.67% of adolescents as obese, compared to 12.47% found here. In this study, however, rates of adolescent overweight and obesity among males were slightly higher and rates among females were slightly lower than YRBS. The YRBS reported 10.88% of females and 10.21% of males were overweight. This compares to 8.57% for females and 11.03% for males in the current study. According to YRBS, 4.38% of females and 8.29% of males were obese. This study found obesity rates of 3.70% for females and 8.77% for males. The increased relative risk of overweight and obesity among select racial and ethnic groups found in this study mirrors trends found in national research. For

American Indians and Black adolescents, the magnitude of the effect was larger than seen nationally.[30]

Maternal BMI had the greatest effect on adolescent overweight and obesity in this study. Because adolescents have experienced years of modeling by their parents, it is not possible to separate the genetic influence of this finding from the influence of the family environment. Parental BMI is a strong predictor of children's BMI throughout childhood.[31] For both males and females, maternal BMI has been shown to have a stronger association with adolescent BMI than paternal BMI in some studies, but not others.[32] The current analysis confirms an association of maternal BMI with adolescent BMI.

However, even when genetic influences have a strong effect, behavioral influences are important.[33] Societal trends such as increased reliance on family cars for transportation, increases in the use of restaurants and prepackaged foods, and decreases in the number of meals eaten together as a family have been attributed to adolescent overweight and obesity.[34] Further research is needed to understand the complexity of genetic influences, family behaviors and adolescent obesity, especially in light of broader school and community characteristics.

School Characteristics

Counter to the original hypothesis, the proportion of students receiving free and reduced price meals conferred a higher risk of overweight and obesity. Prior research in Utah secondary schools found that schools with high participation in the free and reduced price meal program were less likely to offer healthful foods in vending machines or other competitive food venues.[6] The current study found that low participation in the free and reduced price lunch program was associated with obesity. Prior studies have noted a protective or neutral effect of school lunch participation on obesity among low income children and adolescents.[35-36] A similar effect may be taking place in Utah. In addition, the relationship of adolescent obesity and low free lunch participation found in this study may be due to broader factors. Factors such as stigma, open campus policies and family income influence high school student participation in free and reduced meal programs.[37-39]

Research examining the association of parental income with adolescent obesity produces mixed results. Analysis of the National Longitudinal Study of Adolescent Health found an inverse relationship between adolescent obesity prevalence and family income, independent of race or ethnicity and other individual, education and health related covariates.[40] In contrast, recent national surveillance studies in the United States report no association of parental income with child and adolescent obesity by gender and among all races and ethnicities with the exception of white boys. The current study suggests that in Utah, adolescent obesity is prevalent at all levels of parent income.

The finding that the risk of obesity was greater in schools with diverse racial and ethnic populations was not explained by school nutrition and physical activity practices in this study. Other researchers have found disparities in walkability[41] and the number of fast food and convenience stores surrounding schools with a high proportion of Hispanic residents.[42] Unmeasured factors such the built environment surrounding schools or additional individual or family attributes may account for the association of school diversity with adolescent obesity.

School Practices

This study found no association of high school wellness practices with adolescent overweight or obesity. The exception is the practice of exempting students from physical education for another class, which was protective. One explanation is that in a subgroup of schools, parents and students may be more apt to demand exemption from physical education. Separate chi-square analyses, however, found no association of this practice with race, ethnicity, geographic locale or participation in the free and reduced price meal program. This may be a spurious finding given that no other associations of policy and practice were found.

Results suggest the method used to assess school wellness practices was not specific enough to measure obesity prevention practices in high schools. Existing *Profiles* survey data were used due to the availability of multiple years of information on physical activity and nutrition. Responses to *Profiles* questions are limited to a simple yes or no. This clearly cannot capture gradations in the extent of a practice in a school, small changes in practices over time or the full extent of wellness practices in a high school. Further, school districts were given broad leeway in

establishing wellness practices. Policies lack details regarding what is expected of high schools, making statewide evaluation difficult.

This study suggests practices may not be comprehensive enough to produce impacts on adolescent weight. This is supported by previous studies examining the contents of school district wellness policies. These studies suggest the content of the policies are underdeveloped and weak. In the current educational landscape there are priorities competing with school wellness for time, attention and funding. Prior research indicates that school performance initiatives, fund-raising and security issues are perceived as barriers to full policy and practice implementation.[43]

Based on the findings, a final possibility is that school practices may play a smaller role in adolescent obesity prevention than previously hypothesized. This may be particularly true during adolescence, given the strong historic influence of individual and family attributes on current physiology, growth patterns and behaviors. School practices may be most important for a subset of adolescents whose individual and family characteristics put them at greatest risk. Adolescents can be taught about family history and guided towards preventive habits based on their individual risk through innovative health education programs. School personnel can provide reinforcement for behaviors emphasized at home or introduce students to preventive behaviors and environments. There is potential for high school programs and practices to be tailored to the population of the school community and to include family input and participation. Even if the role of schools may be smaller than hypothesized, it remains an important influence on adolescent health and part of the comprehensive approach to obesity prevention.

This study had several strengths. It included individual, family, and school characteristics. This made it possible to examine a large number of previously identified and potential determinants of adolescent overweight and obesity. The sample included a large number of adolescents across the state of Utah. The findings reported in Chapter 2 outline issues with measuring high school wellness practices. This was the primary weakness of the study and may have influenced the ability to detect an effect of practices on adolescent weight. Additionally, height and weight was self-reported by the adolescents. This is a common practice in public

health. However direct measurement is preferred.[44] Self-reported heights and weights are good proxies for measured heights and weights for adolescents over age 14.[45] It is possible that females under-reported their weights and males over-reported their heights to a larger degree in this study than suggested by prior research.[46] In this case, BMI would be artificially lowered making it more difficult to detect an effect. Comparisons to the Utah YRBS suggest this is a possibility for females in the current study, but not likely for males. Finally, adolescents were assigned to school boundaries by their addresses rather than school enrollment. Whether an adolescent was incorrectly assigned to a school is unknown.

Conclusion

Adolescent obesity is the result of a complex set of individual, family, school and policy influences on food and activity behaviors. To date, little progress has been made in decreasing the prevalence of adolescent obesity. Since resources for implementation of wellness practices and other health promotion activities is limited, identifying the most effective and sustainable efforts is essential. The results of this study add to the limited literature on school wellness practices and BMI.

The current implementation of nutrition and physical activity practices in high schools was not associated with adolescent overweight or obesity in Utah. Research is needed to develop tools that quantify wellness policy efforts. Individual and familial attributes have strong associations with adolescent overweight and obesity risk. School characteristics confer additional risk for adolescent obesity. Innovative approaches that include family involvement and prioritize schools with high-risk populations are recommended to advance adolescent obesity prevention.

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CHAPTER 4

A MULTIVARIATE ANALYSIS OF COMMUNITY INFLUENCES ON ADOLESCENT BODY MASS INDEX

Abstract

PURPOSE: To assess the association of community characteristics with adolescent overweight and obesity while controlling for individual, family and school characteristics.

METHODS: Community characteristics were generated from the Behavioral Risk Factor Surveillance system (BRFSS) data collected by the Utah Department of Health (UDOH) for 61 small statistical areas (SSAs) in Utah. Adolescent and family attributes were obtained from the Utah Population Database (UPDB). School characteristics were accessed via the Common Core of Data. Multinomial analyses were performed to model the relationship of community level characteristics with adolescent overweight and obesity.

RESULTS: Four community characteristics were associated with adolescent BMI. The proportion of obese adults in a communities was associated with adolescent overweight (RR_a = 1.45, 95% CI: 1.04-1.24, p<0.008) and obesity (RR_a =1.19,95% CI: 1.05-1.36, p<0.006). When a higher proportion of families in the communities did not have children, the risk of adolescent overweight increased (RR_a =1.26, 95% CI: 1.13-1.41, p<0.001). In communities with a larger proportion of Hispanic residents, adolescents were more likely to be obese (RR_a=1.09, 95% CI: 1.00-1.18, p<0.039). Community education level, measured as the proportion of residents with a college education, was protective for adolescent obesity (RR_a=0.81, 95% CI: 0.69-0.97, p<0.024). The proportion of students receiving free and reduced price lunch was associated with overweight (RR_a = 1.23, 95% CI: 1.10-1.38, p<0.0001) and obesity (RR_a = 1.28, 95% CI: 1.11-1.47),

p<0.001. Community nutrition and physical activity behaviors were not associated with adolescent overweight or obesity.

CONCLUSION: Overweight and obesity are the result of a complex set of individual, family, school and community influences. Adolescent obesity prevention policies and programs should address community disparities in adult obesity, family composition, ethnicity, income and education.

Introduction

Among U.S. adolescents, the prevalence of obesity has tripled since 1980.[1] Adolescent overweight and obesity are of particular concern because the health and economic consequences of obesity may be most detrimental to those who become obese during late adolescence and early adulthood.[2,3] At its core the dramatic increase in obesity prevalence is attributed to increased calorie intake and reduced physical activity. It is clear that the physical environment, such as the accessibility of energy dense foods and lack of opportunities for physical activity, plays a role.[4,5] However, the considerable variation in obesity rates between states, cities and communities likely reflects more than differences in the food and physical environments.[6-8] Changes in diet and physical activity result from a much broader, and more complex, array of social, economic, and cultural factors acting on children's' choices through their parents and siblings, their friends, their neighbors and their schools. Communities are clearly associated with this diverse constellation of factors.

Associations between social factors and obesity by communities are noted for education-level, income, gender and marital status among adults and their children.[7,9] Multilevel studies of adolescents in Canada report significant association between neighborhood socioeconomic status and adolescent obesity after adjusting for parent socioeconomic position.[10] Additionally, national research in the United States indicates that parental health, including obesity, has an association with adolescent obesity, but only among individuals living in extremely disadvantaged communitiess.[11] Results suggest that family history and familial behaviors may play a lesser role in obesity prevention when children and adolescents live in communities where

a high proportion of households receive public assistance, have service level or clerical jobs, have incomes below the poverty level and have high unemployment rates.[11,12]

The link between social and physical characteristics of a communities and obesity is typically framed as an issue of access to healthful foods and physical activity opportunities. For example, children in communities with the best access to grocery outlets report a higher consumption of fruits and vegetables, less consumption of fat and are less likely to be overweight or obese than those living in areas with poor access to grocery outlets.[15] Access to a safe community park is associated with routine physical activity and lower BMI for adolescents.[16,17] In these settings, the relationship of the community environment is directly related to energy balance and risk of obesity. There are also indirect ways that community factors may influence adolescent weight. The attitudes and behaviors of adolescents are thought to be influenced by the health habits of community leaders, social networks of friends[18,19] and the cultural norms for physical activity, eating habits and body size in their communities.[19] It is unknown whether adult nutrition habits or adult physical activity measured at the community level is associated with adolescent BMI.

Further, community collective efficacy, which is a measure of social cohesion and informal social control, is found to be a predictor of adolescent weight.[20,21] Adolescents who live in neighborhoods with low collective efficacy were 52% more likely to be overweight compared to their peers who live in neighborhoods with average levels of collective efficacy.[21] The family composition of households in the community, such as the number of residents per household or the number of children in the family has not been examined for association with youth overweight or obesity. The number of families in a commuity who have children is a potential determinent of social efficacy or other neighborhood factors that influence overweight and obesity.[21]

While these findings shed some light on the underlying factors that are associated with the prevalence of overweight and obesity, the analyses have not included the other crucial determinants of overweight and obesity such as the adolescent's family and the school environment. Maternal BMI is associated with adolescent BMI, but is not included in multivariate models in the current literature. Maternal BMI is related to several family eating behaviors

associated with obesity. These include food preferences,[22] the frequency of restaurant use[23] and the degree to which the mother exhibits restrained eating or dieting.[24] Additionally, parental attitudes towards exercise are shown to influence a child's involvement in physical activity.[19] Nutrition and physical activity behaviors in the home are associated with the mother's education, age and ethnicity.[19]

At school, adolescents are exposed to nutrition and physical education classes as well as a variety of food choices. These are shown to influence the nutritional intake and physical activity[25,26] of adolescents and may be associated with BMI.[27,28] School characteristics, such as the race and ethnicity[27] of the student population and the proportion of students receiving free and reduced price meals have been associated with BMI.[28] The family, school and community are influenced by one another, and jointly influence the risk of overweight and obesity among adolescents.

The objective of this study was to investigate the relationships between community level social and behavioral determinants of adolescent overweight and obesity while controlling for individual, family and school level factors. It was hypothesized that obesity, income, education, ethnicity, family composition, fruit and vegetable intake and physical inactivity measured at the community level would be associated with adolescent overweight and obesity in Utah.

Methods

Data aggregation is described in Figure 7. Individual level data about each subject and their family were taken from the Utah Population Database (UPDB), a population database that includes administrative and genealogical records of Utah residents including birth certificate and driver's license records. For this study UPDB birth certificate data provided information on the maternal age, prepregnancy BMI, maternal marital status and maternal education at the time of the child's birth. The birth certificate was linked to the first issued driver's license, providing information on the residence, sex, race, ethnicity, age and BMI of the child, who is now an adolescent. Community characteristics were generated from the Behavioral Risk Factor Surveillance system (BRFSS) data collected by the Utah Department of Health (UDOH). BRFSS is a national random-digit dialed telephone survey of the noninstitutionalized U.S. civilian

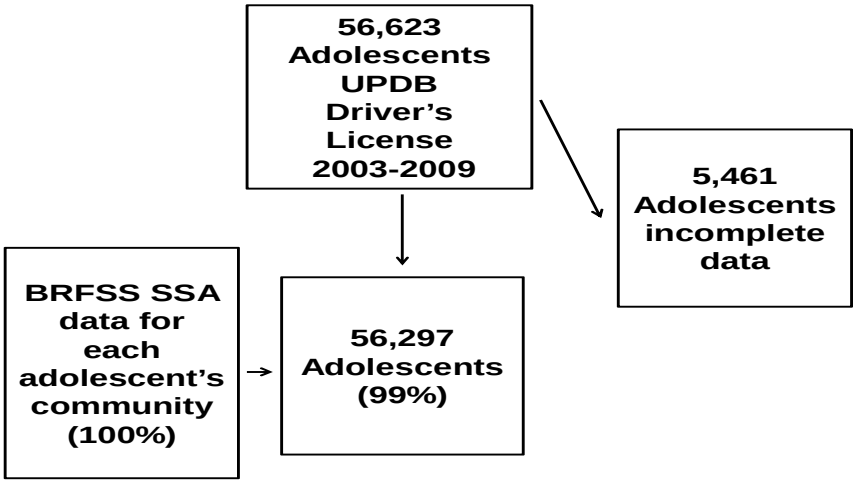

Figure 7. Data Aggregation: Utah Population Database (UPDB) and Behavioral Risk Factor Surveillance Survey (BRFSS) Small Statistical Area (SSA).

population aged ≥18 years. This annual survey collects data on health conditions and health risk behaviors. It is coordinated by the Centers for Disease Control and Prevention (CDC).[29] Population sizes ranged between 20,000 and 40,000 individuals. The size of SSAs varied widely from a few square miles in an urban county to the largest area encompassing four large frontier counties.[29] Weighted summary measures of family income, race and ethnicity, education level, body mass index, fruit and vegetable consumption and the physical activity were generated for each SSA in each year (2003 – 2010). The weights, generated by CDC, account for differences in the probability of selection and differential response rates.[30]

School information was obtained from the Common Core of Data (CCD) compiled by the National Center for Education Statistics.[16] The CCD is updated yearly with information about high schools in the United States. School size, enrollment by race and ethnicity, and the proportion of students receiving free and reduced priced meals were included in this analysis. Each adolescent was linked to his school and community data based on the address listed on his driver's license and the date he obtained his license. School boundary maps were obtained from each school district's website and used to create a geo-referenced data layer using ArcGIS© (version 9.3)[31]. In the case of recent boundary changes, the district was contacted for maps used in 2008. SSA boundaries were created using data provided by the UDOH. The adolescent's address was geo-coded and spatially joined to these layers to identify the high school and SSA associated with his residence. CCD data were linked to each adolescent's record based on the school year the license was received, while BRFSS data was linked based on the calendar year. For BRFSS data that were collected every other year (e.g., physical activity and nutrition data) the data that were temporally closest to the driver's license date were used. The resulting dataset includes communities, individual, family and school characteristics for Utah adolescents receiving their first issued driver's licenses between 2003 and 2009.

Each adolescent's BMI was calculated based on the height and weight reported on the driver's license and then categorized as "normal weight" (less than the 85th percentile for age), "overweight" (at or above the 85th percentile for age but less than the 95th percentile), and "obese

(at or above the 95th percentile for age) based on guidelines from the CDC.[32] Adolescent age, sex, race, and ethnicity were the individual level variables included in the analysis.

Maternal age, race, ethnicity, marital status, educational attainment and BMI were used to describe the adolescent's family. Maternal education was categorized as less than high school, high school, an associate's or bachelor's degree or education beyond a bachelor's degree. Maternal BMI was classified according to the CDC standards for adults. Categories included normal weight/underweight <25.0 kg/m^2, overweight $\geq$25.0 and <30.0 kg/m^2 and obese $\geq$30 kg/m^2.[32]

The school population was described by enrollment, race/ethnicity of the student body and the proportion eligible for free or reduced lunch. School enrollment and the race/ethnicity of the student body were categorized by quartiles. A rural/urban classification provided in the CCD was simplified, grouping schools classified as "rural remote," "rural fringe" and "rural distant" as rural, and all others as urban. The proportion of students eligible for free and reduced price meals was used to create a four level categorical variable (<12.0%, 12-19%, 20- 35% and >35% of the student enrollment).

Each small area was considered a separate community. Definitions for the terminology "neighborhood" versus "community" have not been standardized.[36] Given the variation in the physical size of SSAs, "community" was deemed most appropriate for this study. Categorical variables for each community factor were created based on the estimated proportion of the area that had a given attribute. The cut-points were chosen based on the distributions of the proportions. Characteristics of the small area communities included the proportion of families whose income was above $30,000 per year, the number of children in the household, race, ethnicity and education level. Education level was described as the proportion of adults with a college degree. Community nutritional intake was represented as the proportion of adult respondents who consumed less than 1 serving of fruits and vegetables per day. Physical activity was measured as the proportion of residents who reported no physical activity in the past month.

Multinomial logistic regressions were performed to model the relationship between community characteristics and adolescent overweight and obesity while controlling for individual, family and school characteristics. Multinomial regression was used so that risk of "overweight" and "obese" status could be estimated relative to adolescents who were not overweight or obese. The individual, family and school characteristics described above were included as covariates. The Huber-White modified sandwich estimator was used to adjust for the nonindependence bias that may occur given that adolescent observations are nested within school and communities boundaries.[32] A purposeful backward selection strategy was used to arrive at the final model. Variables were retained if they were significant in either of the component models, or if they were of primary interest for the analysis. When nonsignificant covariates were removed, the effect on the other parameter estimates was noted. Analyses were performed using STATA 10.1 Intercooled©.[33] This research was approved by the University of Utah Institutional Review Board, project number 0024209.

Results

Table 6 describes the distribution of adolescent weight by each covariate. There were 56,297 adolescents included in the final sample. Of these, 46% were male and 54% were female. Adolescents were primarily White (97%). Only 4% of adolescents were Hispanic. The majority of adolescents (63%) were 16 years old. Twenty-three percent were age 17, 11% were over age 17 and 3% were 15 years old.

Overall 83% of the sample adolescents were not overweight or obese, 10% were overweight and 7% were obese. The distribution of maternal weight status was 68% not overweight or obese, 30% overweight and 2% obese. The large majority of adolescents lived in urban areas, with 6% residing in rural areas.

The results of the final model are presented in Table 7. Several individual and family characteristics affected the relative risk of both overweight and obesity when compared to not overweight or obese. Of these, maternal BMI had the strongest effect. Adolescents whose mothers were obese had the highest risk of obesity with a relative risk of 7.03 (6.43-7.70, $p<0.001$). Adolescents whose mothers were overweight had an elevated risk of obesity of

Table 6. Sample Characteristics by Adolescent Body Mass Index, n= 56,297 (99.42%)

		Body Mass Index			
		Not overweight	**Overweight**	**Obese**	**p-value**
		n= 46,841	**n = 5,910**	**n= 3,872**	
		82.72%	10.44%	6.84%	
	%	**%**	**%**	**%**	
Sex					0.0001
Male	54.09	79.74	11.20	9.07	
Female	45.91	86.17	9.45	4.38	
Age (years)					0.001
15	2.85	80.98	11.80	7.22	
16	62.50	83.88	9.88	6.25	
17	23.32	80.90	11.23	7.87	
18	7.71	79.96	11.38	8.66	
19	3.62	83.56	9.98	6.46	
Race					0.0001
Black	0.26	62.36	19.01	18.63	
American Indian	0.61	62.15	18.27	19.58	
Polynesian	1.30	71.15	14.73	14.12	
Asian	0.52	86.37	7.29	6.33	
White	97.19	83.01	10.28	6.70	
Other/Unknown	0.11	79.46	9.82	10.71	
Ethnicity					0.001
Non-Hispanic	95.55	83.11	10.21	6.68	
Hispanic	4.45	73.76	14.29	11.94	
Mother's age (years)					0.001
<20	6.30	77.96	12.79	9.25	
20-29	59.44	82.85	10.38	6.76	
30-39	32.50	83.31	9.97	6.72	
>=40	1.76	82.71	10.11	7.18	
Mother's marital status					0.0001
Not Married	8.62	74.35	14.37	11.28	
Married	91.38	83.48	10.02		
Mother's education					0.001
<12 years	9.84	75.60	13.70		
12-14 years	35.48	80.62	11.43	7.95	
15-16 years	35.42	84.43	9.49	6.09	

Table 6 continued

		Body Mass Index			
		Not overweight	**Overweight**	**Obese**	**p-value**
		n= 46,841	**n = 5,910**	**n= 3,872**	
		82.72%	**10.44%**	**6.84%**	
	%	%	%	%	
>16 years	19.17	87.03	8.42		
Mother's BMI					
Not overweight	73.82	93.04	13.70	6.52	0.001
Overweight	17.16	74.61	15.20	10.19	
Obese	9.02	59.33	18.93	21.75	
Geographic locale					0.0014
Rural	11.35	82.84	10.30	6.85	
Urban	88.35	81.85	11.10	7.37	
School enrollment					0.001
<500	10.77	81.92	11.`13	6.95	
500-1200	13.83	82.77	10.26	6.96	
1201-2000	24.47	81.78	10.60	7.61	
>2000	50.92	83.27	10.18	6.56	
Free and reduced price meal eligibility					0.001
<15%	25.89	86.53	8.70	4.77	
15-29%	25.17	83.80	9.73	6.47	
30-50%	32.59	81.19	11.21	7.60	
>50%	16.34	77.90	12.48	9.62	
School Diversity Proportion White students					0.0001
>70%	46.78	86.22	8.97	4.81	
24-70%	25.76	83.83	9.79	6.30	
<24%	27.46	81.21	11.02	7.76	
Neighborhood ethnicity					0.0001
<10% Hispanic	67.39	83.80	9.94	6.27	
>10% Hispanic	32.61	80.41	11.34	8.25	
Neighborhood income					0.0001
<25% college	33.04	79.16	11.99	8.85	

Table 6 continued

		Body Mass Index			
		Not overweight	**Overweight**	**Obese**	**p-value**
		n= 46,841	**n = 5,910**	**n= 3,872**	
	%	%	%	%	
25-50% college	57.92	84.04	9.75	6.21	
>50% college	9.04	86.96	8.70	4.34	
Neighborhood family composition Proportion no children					0.4705
<30%	10.65	84.45	9.08	6.47	
30-50%	82.19	82.19	10.64	7.17	
>50%	83.13	83.13	10.36	6.52	
Neighborhood obesity					0.001
<20%	16.88	85.24	9.24	5.52	
20-30%	52.13	83.04	10.20	6.66	
>30%	30.00	80.71	11.19	8.10	
Neighborhood fruit & vegetable intake <=1 serving/day					0.001
<10%	88.20	83.08	10.22	6.70	
>10%	11.80	79.80	11.71	8.49	
Neighborhood physical activity No physical activity					0.001
<10%	83.59	83.05	10.25	6.69	
>10%	16.41	80.84	11.12	8.04	

Neighborhood obesity, family composition, ethnicity, education, income, fruit and vegetable intake and physical activity were derived from the Behavioral Risk Factor Surveillance Survey Small Statistical Areas. Adolescent sex, age, race, ethnicity, height and weight were obtained from the first state-issue driver's license. School locale, enrollment, free or reduced price meal eligibility were obtained from the National Center for Education Statistics Common Core of Data. Mother's prepregnancy BMI height and weight, marital status, education and age were obtained from the child's birth certificate.

Table 7. Risk Ratios (RR) and 95% Confidence Intervals (CI) from Multinomial Logistic Regression of the Likelihood the Adolescent Is Overweight or Obese by Neighborhood, School and Individual Characteristics, n=56,297 (99.42%).

	Overweight	p-value	Obese	p-value
Neighborhood obesity				
<20% BMI obese	1.0		1.0	
20-30% obese	1.14 (1.03-1.25)	0.006	1.08 (0.96-1.22)	0.024
>30% obese	1.15 (1.04-1.24)	0.008	1.19 (1.05-1.36)	0.006
Neighborhood family composition				
<30% no children	1.0		1.0	
30-50% no children	1.21 (1.09-1.34)	0.001	1.08 (0.95-1.23)	0.222
>50% no children	1.26 (1.13-1.41)	0.001	1.07 (0.94-1.24)	0.286
Neighborhood ethnicity				
<10% Hispanic	1.0		1.0	
>10% Hispanic	1.05 (0.981-1.12)	0.168	1.09 (1.00-1.18)	0.039
Neighborhood college education				
<25% college	1.0		1.0	
25-50% college	0.96 (0.88-1.04)	0.27	1.02 (0.92-1.12)	0.744
>50% college	0.92 (0.80-1.04)	0.195	0.81 (0.69-0.97)	0.024
Neighborhood income				
<15% $30,000+	1.0		1.0	
15-40% $30,000+	1.03 (0.95-1.13)	0.390	0.99 (0.90-1.11)	0.934
>40% $30,000+	1.07 (0.95-1.20)	0.260	0.87 (0.75-1.01)	0.072
Neighborhood fruit & vegetable intake				
<10% 1 serving/ day	1.0		1.0	
≥10% 1 serving/day	1.06 (0.96-1.17)	0.221	0.99 (0.88-1.12)	0.906
Neighborhood physical activity				

Table 7 continued

	Overweight	p-value	Obese	p-value
<10% no PA	1.0			
≥10% no PA	0.97 (0.89-1.06)	0.508	1.04 (0.941.15)	0.411
Geographic Locale				
Urban	1.0		1.0	
Rural	1.03 (0.96-1.13)	0.564	0.96 (0.85-1.08)	0.504
School Diversity Proportion White students				
>70%	1.0		1.0	
24-70%	1.03 (0.96-1.11)	0.428	1.10 (1.00-1.21)	0.044
<24%	0.96 (0.79-1.16)	0.664	1.18 (0.95-1.47)	0.131
Free and reduced price meal eligibility				
<15%	1.0		1.0	
15-29%	1.05 (0.97-1.15)	0.23	1.34 (1.02-1.27)	0.026
30-50%	1.13 (1.02-1.24)	0.016	1.10 (0.97-1.24)	0.145
>50%	1.23 (1.10-1.38)	0.001	1.28 (1.11-1.47)	0.001
Sex				
Female	1.0		1.0	
Male	1.37 (1.30-1.45)	0.001	2.49 (2.31-2.68)	0.001
Age				
15	1.0		1.0	
16	0.81 (0.69-0.95)	0.009	0.85 (0.69-1.04)	0.111
17	0.88 (0.74-1.03)	0.114	0.94 (0.76-1.16)	0.561
18	0.88 (0.73-1.05)	0.158	0.95 (0.75-1.20)	0.666
19	0.73 (0.59-0.90)	0.004	0.69 (0.5300.91)	0.008
Race				
White	1.0		1.0	
Black	1.71 (1.07-2.73)	0.025	2.51 (1.51-4.16)	0.001
American Indian	1.60 (1.17-2.12)	0.003	2.66 (1.96-3.61)	0.001
Pacific Islander	1.43 (1.14-1.79)	0.002	2.02 (1.61-2.54)	0.001
Asian	0.78 (0.50-1.21)	0.272	1.26 (0.77-2.04)	0.349
Unknown	1.22 (0.53-2.76)	0.642	1.87(0.79-4.42)	0.793

Table 7 continued

	Overweight	p-value	Obese	p-value
Ethnicity				
Non-Hispanic	1.0		1.0	
Hispanic	1.19 (1.05-1.35)	0.006	1.31 (1 13-1.51)	0.001
Mother's BMI				
Not overweight	1.0		1.0	
Overweight	2.01 (1.88-2.15)	0.001	2.57 (2.36-2.79)	0.001
Obese	3.15 (2.90-3.42)	0.001	7.03 (6.43-7.70)	0.001
Mother's Education				
<12 years	1.0		1.0	
12-14 years	0.88(0.79-0.97)	0.013	0.81(0.71-0.91)	0.001
15-16 years	0.75(0.67-0.84)	0.001	0.65 (0.57-0.74)	0.001
>16 years	0.71 (0.62-0.81)	0.001	0.53 (0.46-0.62)	0.001
Mother's marital status				
Married	1.0		1.0	
Not married	1.35 (1.23-1.49)	0.001	1.46 (1.29-1.65)	0.001
Mother's age				
<20 years	1.0		1.0	
20-29 years	0.95 (0.84-1.07)	0.403	0.81 (0.69-0.94)	0.005
30-39 years	0.89 (0.78-1.02)	0.091	0.79 (0.67-0.93)	0.004
>=40 years	0.84 (0.66-1.08)	0.170	0.81 (0.61-1.09)	0.169

Neighborhood obesity, family composition, ethnicity, education, income, fruit and vegetable intake and physical activity were derived from the Behavioral Risk Factor Surveillance Survey Small Statistical Areas. Adolescent sex, age, race, ethnicity, height and weight were obtained from the first state-issue driver's license. School locale, enrollment, free or reduced price meal eligibility were obtained from the National Center for Education Statistics Common Core of Data. Mother's prepregnancy BMI height and weight, marital status, education and age were obtained from the child's birth certificate.

2.57 (2.35-2.79, p<0.001). When an adolescent's mother was overweight, adolescent risk of overweight was 2.01(1.86-2.15, p<0.001) and when the mother was obese, adolescent risk of overweight was 3.15 (2.90-3.42, p<0.001).

Boys had an appreciable increase in risk of obesity and a notable increase in overweight compared to girls, with a relative risk for obesity of 2.49 (2.31-2.68, p<0.001) and for overweight of 1.37 (1.30-1.45, p<0.00). The race and ethnicity of the adolescent affected the risk of overweight and obesity considerably. Black adolescents had a relative risk of obesity of 2.51 (1.96-3.63, p<0.001) and a relative risk of overweight of 1.71 (1.07-2.73, p<0.003) when compared to their White counterparts. American Indian adolescents had 2.66 (1.96-3.61, p<0.001) times the risk of obesity and 1.60(1.17-2.12, p<0.001) times the risk of overweight of White adolescents. The relative risk of obesity for Polynesian adolescents was 2.02 (1.61-2.54, p<0.001) and the relative risk of overweight was 1.43 (1.14-1.79, p<0.002) times that of White teens.

The racial and ethnic diversity of the school population was not significant for adolescent overweight but had a modest effect on obesity at 1.10 (1.00-1.21, p<0.04). The proportion of adolescents receiving free and reduced price meals was significant for both overweight and obesity. When the proportion of students receiving free and reduced price meals was >50%, the relative risk of overweight was 1.23 (1.10-1.38, p<0.00) and the risk of obesity was 1.28 (1.11-1.47, p<0.001).

The proportion of obese adults in the SSA was the community characteristic that had the greatest effect on both adolescent overweight and obesity. When the proportion of obese adults was 20-30%, the relative risk of overweight for adolescents was 1.14 (1.03-1.25, p<0.006) compared to community where the proportion of obese adults was <20%. Results were the same when the proportion increased to >30% at 1.15 (1.04-1.25, p<0.008). Adolescents were most likely to be obese when community obesity was >30%. In this case, adolescent obesity risk was 1.19 (1.05-1.36, p<0.006).

Adolescent obesity risk was elevated in areas with more than 10% Hispanic residents at 1.09 (1.00-1.18, p<0.039). Adolescents living in a communities where 50% or more of the adults

have a college degree had a decreased risk of obesity at 0.81 (0.69-0.973, p<0.024) compared to communities where <25% of adults had a college degree. There was no effect of education on adolescent overweight. When a community had a higher proportion of households with no children the risk of adolescent overweight, but not obesity, was increased. In communities where more than 50% of households had no children the relative risk of overweight was 1.26 (1.13-1.21, p < 0.001). There was no significant effect of the proportion of community households with incomes greater than $30,000 per year on adolescent overweight and obesity. The proportion of students receiving free and reduced price meals was associated with adolescent overweight and obesity. At eligibility levels >50% of the school enrollment, the risk of overweight was 1.23 (1.10-1.38, p<0.001) and the risk of obesity was 1.28 (1.11-1.47, p<0.001).

Neither community nutrition patterns nor physical activity behaviors was associated with overweight or obesity. There was no significant difference in adolescent weight status when the proportion of those eating < 1 serving of fruits and vegetables was less than 10% compared to those in which the proportion was 10% or greater. This relationship was also tested using the proportion of the communities that consumed five fruits and vegetables versus those who did not and the relationship remained insignificant. Physical activity was not associated with adolescent overweight or obesity. When fewer than 10% of community respondents report they are not physically active, there was no difference in adolescent overweight and obesity compared to communities in which 10% or more of the communities reports inactivity. There was also no significant association between the proportion of community respondents who reported meeting national physical activity guidelines and weight status of adolescents.

Discussion

The goal of this study was to measure the contribution of community social and behavioral factors to adolescent overweight and obesity risk while controlling for individual, family and school characteristics. Four community characteristics were associated with adolescent weight status: proportion of adults who were obese, without children, Non-White, and with a college education.

The proportion of overweight and obese adults in the communities had the strongest effect on the risk of adolescent overweight and obesity. This finding likely reflects a combination of social influences, adult modeling of health behaviors and genetic influences of parents.[34] In communities where a higher proportion of adults are overweight or obese, cultural norms for body size and health behaviors may influence adolescent attitudes and behaviors.[35] Further work to determine the physical characteristics of these communities may provide additional information on their unique characteristics. The results of this study confirm that communities with a high proportion of overweight and obese adults are appropriate targets for adolescent obesity prevention programs.

The results of this study indicate that adolescents are at greater risk of being overweight when they live in a community that has a higher proportion of households without children. Other studies that examine this neighborhood dynamic are not available. However, the number of members of a household has been shown to have no effect on adult obesity.[7] A possible explanation for the result found here is that adolescents may have fewer opportunities for socialization and physical activity with other adolescents when they live in a neighborhood with few peers. Conversely, there may be characteristics of families with children that influence community nutrition and physical activity behaviors. Neighborhoods with children may have more green space, fitness centers or sports teams making it easier for adolescents to participate in physical activity. The age of the homes in the neighborhood was not available for the current analysis, but has been found to influence child and adolescent obesity. Nationally, adolescents living in older suburban neighborhoods have been found to be more active and less likely to be obese,[36] while other researchers have found that children living in more recent housing developments are more likely to be overweight.[13] It is possible that families with no children chose to live in a certain type of community. Future studies should consider the influence of the physical environment when communities are composed of small or large families.

In neighborhoods that have a higher proportion of Hispanic adults, adolescents had an increased risk of obesity, but not overweight. Previous studies have shown that the density of fast food restaurants and food advertising is higher in Hispanic neighborhoods than in

predominately White neighborhoods.[37,38] Additionally, the acculturation of the mother has been shown to influence child obesity. Hispanic mothers who are less acculturated in terms of language and socialization with those outside their family are more likely to have obese children.[39] The effect of acculturation and other potential barriers to obesity prevention merits further study as Utah and other mountain states become more ethnically diverse.

Finally, higher education levels of the community are associated with lower risk of adolescent obesity. The association of educational attainment and BMI among adults is well documented and the relationship has remained stable since 1971.[40,41] Less educated White men and women and younger Black women are more likely to be obese than college graduates.[40,42] The finding that community education level was associated with adolescent weight has been demonstrated previously. For example, researchers in St. Louis found that community education predicted adolescent BMI while controlling family education and occupation. Education has been shown to influence parenting styles and child obesity.[42] It is possible that parents in highly educated communities have more knowledge of nutrition and physical activity recommendations for adolescents and this creates social support for these behaviors outside of the home. Adults in these communities may be more likely to encourage adolescents to modify their nutrition behaviors and participate in physical activity at school, work or during social activities.

Based on previous research, it was hypothesized that income would be associated with adolescent BMI. While no effect was found for community household income, the proportion of students eligible for free and reduced price lunch was significant. It is likely the income level chosen for the community level income variable did not capture an effect that was shown with free and reduced price lunch eligibility.

Similarly, race was associated with adolescent overweight and obesity in the bivariate analyses, but not in the full model. These effects may have been captured by the ethnicity and education variables and merit further study.

It is possible that the location or place of interest, such as home, school or community, is associated with several factors. Models were run without the individual attributes and maternal BMI to test for effect size changes in community variables. When the model did not control for

these variables, the effect sizes of the community variables did not change. This gave further support for an effect of community beyond that of individual and family factors.

No other studies have included school factors or mother's BMI when examining community factors and adolescent obesity. The primary strength of the study is the inclusion of multiple factors at individual, family, school and community levels. The study had a unique ability to link a large number of adolescents to their larger school boundary and small area community while prior studies have been limited to less than 10,000 children or adolescents.[16] This study was limited to social and behavioral factors in the community. Characteristics of the built environment were not included. There were other limitations to the study. Communities were limited to the previously designated small areas of Utah. These boundaries were selected with public input and the goal of creating homogeneity within each area; however the economic and social cohesion of these areas is unknown. The family level attributes are limited to maternal characteristics at the time of birth. While these provide valuable insight, a more complete picture of the family unit would be provided with the inclusion of paternal and sibling attributes. School characteristics were limited to those found significant in a prior study of Utah high school practices and adolescent obesity. It would be helpful to have a more comprehensive set of school characteristics and practices.

Community selection was the final limitation of this study. This limitation is inherent in the neighborhood and community level health literature.[43] Individuals and families choose where they live; therefore community selection is not random. Individuals choose communities based on the reputation of neighborhood schools, the race, income level and education level of the community members.[43] With respect to weight, the relationship of community selection is reported to go in both directions. That is, BMI is shown to be both a determinant of the choice of a neighborhood and a factor in weight gain or loss once an individual moves to a new neighborhood.[44] The study described here is strengthened by the fact that adolescents have little choice in where they live. Community selection was less of a factor, making the influences conferred by the community more relevant.

The results of this study reinforce the importance of addressing community determinants of adolescent obesity. This study confirms that communities that have a higher proportion of overweight and obese adults should be prioritized for adolescent obesity prevention programs. More importantly, effective adolescent obesity prevention interventions should address social factors that extend beyond the health care system.

Several topics for future studies are suggested. Further exploration of the mechanism by which community obesity influences adolescent obesity, the effect of the number of children in a community, and the social or built environment of Hispanic communities is warranted. Further research is needed to address the influence of communities on adolescent obesity in the context of family influences, school characteristics and individual attributes. Methods to quantify school nutrition and physical activity practices are especially needed, so their role in obesity prevention can be defined in relation to community factors. Research that includes the physical environment and the social cohesion of communities is a natural progression from the social factors studied here. Additionally, there is limited research conducted at the state level by small areas or communities. As obesity prevention advances, local information is best suited to inform effective health messages and citizen involvement. A clear understanding of the relative contribution of each aspect of adolescent life to weight health will assist communities in establishing focused programs and policies that have the best opportunity for success.

Conclusion

Adolescent obesity is the result of a complex set of genetic, social and behavioral factors. Research is beginning to uncover the role that each factor plays in the development and prevention of overweight and obesity. As obesity prevention efforts advance, understanding disparities within communities can assist efforts to tailor interventions at the local level.

This study found several community factors were associated with adolescent overweight and obesity in Utah, while controlling for individual, familial and school factors. The findings of this study reinforce the importance of a comprehensive approach to adolescent obesity prevention that focuses on each component of adolescent life. It also illustrates the importance of multisector approach since the neighborhood characteristics associated with obesity extend

beyond health behaviors. Results suggest that programs and policies will not be effective if they focus on individual behavioral change, family influences or school practices without consideration of the broader community in which adolescents live.

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CHAPTER 5

CONCLUSION

The purpose of this study was to investigate the influence of schools and communities on adolescent overweight and obesity in Utah. The study first examined whether high school obesity prevention practices changed as a result of the federal wellness policy mandate implemented in 2006. It included an analysis of the relationship of high school practices to adolescent overweight and obesity while controlling for individual and family characteristics. Finally, the relationship of community characteristics with adolescent overweight and obesity was assessed while controlling for individual, family and school characteristics. Together, these analyses provide a picture of potential determinants of adolescent overweight and obesity at several levels of the socioecologic model: individual, family, school, community and policy.[1,2] Results and recommendations are summarized below.

Did High School Obesity Prevention Practices Change from 2004-2008?

Overall, there were few changes in high school nutrition and physical activity practices after the federal wellness policy mandate. For many of the nutrition and physical activity practices measures, adherence was at 90-100% prior to the wellness policy deadline and remained high following the mandate. A very high proportion of health teachers reported teaching nutrition and physical activity concepts in health education courses. These topics included basic nutrition and physical activity information aimed to increase knowledge. The topics that were reported by less than 90% of teachers were those that discussed application of specific behaviors or strategies for overcoming barriers to eating well or participating in physical activity.

The school competitive food environment did not change during the study time frame. Candy, chips, baked goods, and sugar-sweetened beverages were sold in 90-100% of high schools in Utah both pre and post the wellness policy deadline. Further, when the proportion of schools selling a competitive food changed, it was not due to schools that sustained the practice over time. Despite this, schools almost universally reported they have a policy that fruits and vegetables are offered at parties and celebrations.

More than 95% of principals in Utah indicate their schools teach physical education and employ a certified physical education instructor. In 60% of schools there was a least one way a student could be exempt from physical education including participation in a school or community sport, enrollment in another course or participation in a school club or activity. There was a modest increase in the number of schools that provided nutrition and physical activity training for their teachers. Health teachers and physical education teachers report they collaborate on school health activities. The proportion of health teachers who collaborate with food service personnel increased over time but just 25% of health teachers reported this practice.

It was hypothesized there would be variation in school practices by school characteristics, including the size of the school, the race and ethnicity of the student population, the proportion of students receiving free and reduced price lunch and whether the school was rural or urban. No associations of school characteristics and school practices were found.

High school compliance with school district wellness policies was measured in two ways. First, the content of school policies was compared to the content of high school practices in three areas: nutrition, physical activity and training/collaboration. No associations were found. It was further hypothesized that schools within a district would have similar practices since they have the same wellness policy. This analysis found no association of school practices among high schools in the same school district.

Together, these findings suggest that the school district wellness policies did not result in comprehensive modification of high school obesity prevention practices. It is possible that small changes in practices were made that were not detected. The *Profiles* survey framed all question responses as ‘yes’ or ‘no’. It is likely this instrument was too blunt and did not capture potential

gradations in school practices. At the same time, other researchers have noted that compliance with wellness policies has been weak due to the unfunded nature of the mandate, lack of specific policy standards and limited evaluation.[3] Going forward, it is recommended that school district wellness policies contain guidelines for high schools that are clear and specific. Additionally, it is critical to develop measurement tools that can assess whether or not schools are changing the school environment in response to district policies. The research described here suggests that the tool needs to be able to capture incremental changes since practice improvements may not be captured with a yes or no response. For example, high schools may reduce the number of vending machines available or minimize the number of slots available used for sugar sweetened beverages (SSBs). This would be reported as 'yes' when principals respond to 'are SSBs are available to students?' and the incremental change would not be noted. It also needs to address practices specific to the wellness policy rather than nutrition and physical education practices that were in place before the wellness policy initiative. *Profiles* is not an appropriate tool for measuring these practice changes.

What Is the Relationship of High School Obesity Prevention Practices and Adolescent Overweight and Obesity?

This analysis used data from a variety of secondary sources to look at nutrition and physical activity practices in high schools and potential associations with adolescent obesity within school boundaries. The data provided a unique opportunity to examine a large number of adolescents with a diverse set of individual, family and school characteristics as covariates. School practices were obtained from the *Profiles* data previously described. The outcome variable was BMI which was calculated from the height and weight on the adolescent's driver's license. School characteristics were obtained from the Common Core of Data and family characteristics were obtained from the child's birth certificate.

There were no associations detected between school practices and adolescent body mass index. The practices included in the model included school health education class topics, competitive food options, exemptions from physical education, training of health teachers and collaboration among health teachers, physical education teachers and food service personnel.

Given the large sample size, there was adequate power to detect a significant effect if it was present. The lack of association may have been affected by how the data were collected. The *Profiles* survey is a crude tool that may not provide a complete picture of wellness practices in high schools. Additionally, principals may not be an accurate source of information on competitive foods and physical education practices.[4] It is a possibility that under-reporting of weight or over-reporting of height contributed to the lack of association. However, self-reported heights and weights have been shown to be good proxies for measured heights and weights for adolescents over age 14.[5]

These results suggest that the high school environment may play a smaller role in adolescent obesity than family, individual or broader school influences. This was supported by the increases in relative risk of overweight and obesity by sex, maternal characteristics, school diversity and free and reduced lunch eligibility. Clearly, even if school practices play a small role, they remain a part of the broad societal response necessary to prevent obesity. Future research should examine the influence of the revised federal wellness policy which will be implemented in 2012. This policy includes specific guidelines for competitive foods and enhances reporting and evaluation requirements. It is critical to determine whether these measures will strengthen practices at the scale necessary to impact adolescent body mass index. To do so will require monitoring tools that can better capture the level of implementation, attitudes regarding implementation among administrators, teachers and students, and study designs that capture such data before and over time following the policy adoption.

What Is the Relationship of Community Characteristics with Adolescent Overweight and Obesity?

The influence of the larger community on adolescent obesity was examined by using small statistical area data from the Utah BRFSS. The BRFSS data provided information on adult characteristics and behaviors for 61 small area communities in Utah. These data were included in the final analysis along with significant individual, family and school characteristics from the prior analyses. It was hypothesized that adolescent obesity would be associated with community socio-demographic factors, obesity rates and nutrition and physical activity behaviors.

In this analysis, community obesity was associated with adolescent overweight and obesity. Adolescents in communities where more than 25% of adults were obese had a 14% higher risk of overweight compared to those living in community with fewer obese adults. Those adolescents living in communities where at least 30% adults were obese had a 20% higher risk of obesity. Several other social characteristics of communities were associated with either overweight, obesity or both. While no associations were found for household income, the proportion of students receiving free and reduced price meals was associated with adolescent overweight and obesity. Living in communities that had a higher proportion of Hispanic adults put adolescents at greater risk of obesity. In communities in which a high proportion of adults have a college education adolescents had less risk of obesity. In communities with a higher proportion of families with no children there was less risk of adolescent overweight.

Community level nutrition and physical activity behaviors were not associated with adolescent overweight and obesity. These measures included the proportion of community respondents who reported inadequate or adequate fruit and vegetable consumption and the proportion of community respondents who reported physical inactivity or met physical activity recommendations.

In this analysis the individual and maternal attributes that were significant were the same attributes found to be significant in the school analysis described above. Of these, maternal BMI had the strongest association. An adolescent had seven times the relative risk of being obese when the mother was obese compared with mothers who were not overweight or obese. When the mother was overweight, the relative risk of adolescent overweight and obesity was two to three times higher compared to normal weight mothers. Adolescents whose mothers were married, had education beyond high school, and were not Hispanic had a lower risk of overweight and obesity. Having a mother who was at least 20 years old at the time of the child's birth was protective for adolescent obesity. Several individual attributes increased the relative risk of obesity. Being male, Black, American Indian, or Pacific Islander was associated with relative risks of 2.0 to 2.6 times that of female and White adolescents.

The results of this analysis confirm that community characteristics are associated with adolescent obesity and are independent of individual, maternal and school characteristics. Study results suggest that broad community factors influence adolescent obesity and are appropriate considerations for prevention efforts.

This study suggests social change that extends beyond public health or health care is necessary for obesity prevention. It is critical to address the income and education level disparities that are associated with adolescent obesity. Additionally, there may be disparities in the physical characteristics of the community. Future studies should examine the features of communities such as food outlets, green space, recreation centers and urban design. The relationship of social efficacy, household composition and adolescent overweight and obesity is worth exploring. These results suggest that community based participatory research at the community level may be an effective method for understanding how individuals and families can mobilize their efforts to address the social and physical characteristics of their community to prevent obesity.

Summary

It is estimated that 83% of men and 72% of women in the United States will be overweight or obese by 2020.[6] Adolescence is a critical period in the development of adult overweight and obesity. In order to prevent this rapid acceleration in obesity rates, changes are needed in individual and family behaviors, school practices and community norms. This research suggests areas for improvement in the school setting and potential research in the individual, family and community settings.

Implementation and evaluation of wellness policies should be improved in high schools. As new policies are developed in 2012, they should outline specific practices that can be monitored and evaluated. Tools are needed that measure changes in high school practices that are specific to the wellness policy mandate. It is also important to engage administrators, teachers and students in implementing wellness practices and to provide them with adequate resources so that practices can be sustained over time. With these pieces in place, the influence of school practices on adolescent BMI can be reassessed.

Future research should further explore how adolescent behavior is influenced by school wellness policies and community characteristics. It would be useful to include the physical characteristics of Utah communities in the model described in Chapter 4. Research is needed that includes the concentration of food outlets, parks, recreation centers, and the design of sidewalks and streets in each small statistical area. On the family level, policies and programs are suggested to assist parents with adolescent obesity prevention strategies. It would be useful to include the physical characteristics of Utah communities in the model described in Chapter 4. Research is needed that includes the concentration of food outlets, parks, recreation centers, and the design of sidewalks and streets in each small statistical area. Research on the family composition of communities and adolescent overweight should be further explored. Finally, the community level disparities in adolescent overweight and obesity by race, ethnicity, education and income deserve public health and policy action.

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